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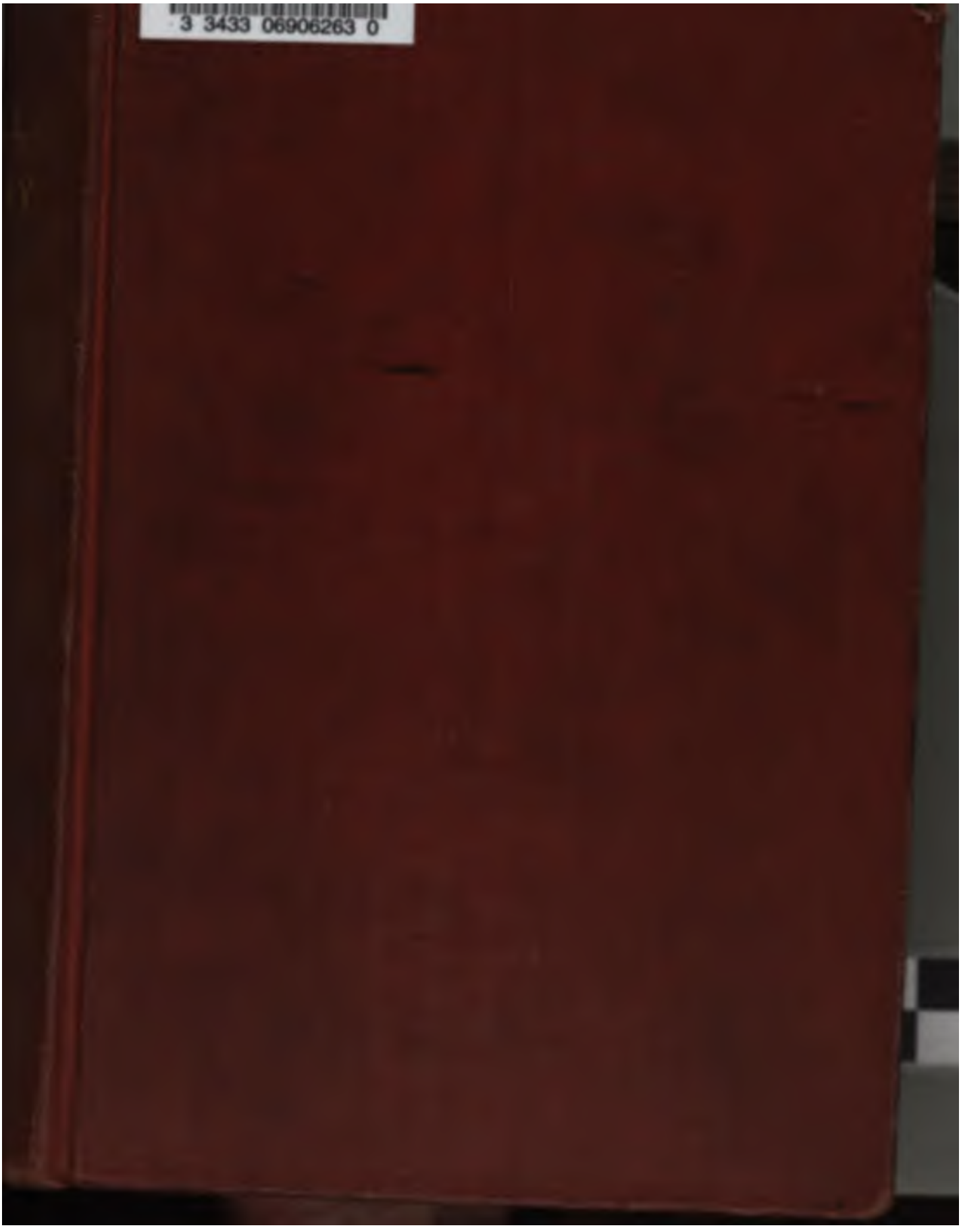
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Linear.					Capacity.							
Inches to Millimeters.	Feet to Meters.	Yards to Meters.	Miles to Kilometers.		Drams to Cubic Centimeters.	Ounces to Millimeters.	Quarts to Liters.	Gallons to Liters.	Cubic Inches to Cubic Centimeters.	Cubic Feet to Cubic Meters.	Cubic Yards to Cubic Meters.	Bushels to Hectoliters.
25·4000	0·304801	0·914402	1·60935	= 1 =	3·70	29·57	0·94636	3·78544	16·387	0·02832	0·765	0·35242
50·8001	0·609601	1·828804	3·21869	= 2 =	7·39	59·15	1·89272	7·57088	32·774	0·05663	1·529	0·70485
76·2001	0·914402	2·743205	4·82804	= 3 =	11·09	88·72	2·83908	11·35632	49·161	0·08496	2·294	1·05727
101·6002	1·219202	3·657607	6·43739	= 4 =	14·79	118·30	3·78544	15·14176	65·549	0·11327	3·058	1·40969
127·0002	1·524003	4·572009	8·04674	= 5 =	18·48	147·87	4·73180	18·92720	81·936	0·14158	3·823	1·76211
152·4003	1·828804	5·486411	9·65608	= 6 =	22·18	177·44	5·67816	22·71264	98·323	0·16990	4·587	2·11454
177·8003	2·133604	6·400813	11·26543	= 7 =	25·88	207·02	6·62452	26·49808	114·710	0·19822	5·352	2·46696
203·2004	2·438405	7·315215	12·87478	= 8 =	29·57	236·59	7·57088	30·28352	131·097	0·22654	6·116	2·81938
228·6004	2·743205	8·229616	14·48412	= 9 =	33·28	266·16	8·51724	34·06896	147·484	0·25485	6·881	3·17181

Square.					Weight.				
Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectares.		Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds to Kilograms.	Troy Ounces to Grams.	
6·452	9·290	0·836	0·4047	= 1 =	64·7989	28·3495	0·45359	31·10348	
12·903	18·581	1·672	0·8094	= 2 =	129·5978	56·6991	0·90719	62·20696	
19·355	27·871	2·508	1·2141	= 3 =	194·3968	85·0486	1·36078	93·31044	
25·807	37·161	3·344	1·6187	= 4 =	259·1957	113·3981	1·81437	124·41392	
32·258	46·452	4·181	2·0234	= 5 =	323·9946	141·7476	2·26796	155·51740	
38·710	55·742	5·017	2·4281	= 6 =	388·7935	170·0972	2·72156	186·62089	
45·161	65·032	5·853	2·8328	= 7 =	453·5924	198·4467	3·17515	217·72437	
51·613	74·323	6·689	3·2375	= 8 =	518·3914	226·7962	3·62874	248·82785	
58·065	83·613	7·525	3·6422	= 9 =	583·1903	255·1457	4·08233	279·93133	

1 chain	=	20·1169 meters.
1 square mile	=	259 hectares.
1 fathom	=	1·829 meters.
1 nautical mile	=	1853·27 meters.
1 foot = 0·304801 meter,		9·4840158 log.
1 avoir. pound	=	453·5924277 gram.
15432·35639 grains	=	1 kilogram.

TABLES FOR CONVERTING METRIC TO UNITED STATES WEIGHTS AND MEASURES.

Linear.					Capacity.							
Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.		Milliliters or Cubic Centiliters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Dekaliters to Gallons.	Hectoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
39·3700	3·28083	1·093611	0·62137	= 1 =	0·27	0·338	1·0567	2·6417	2·8375	0·0610	35·314	1·308
78·7400	6·56167	2·187222	1·24274	= 2 =	0·54	0·676	2·1134	5·2834	5·6750	0·1220	70·629	2·616
118·1100	9·84250	3·280833	1·86411	= 3 =	0·81	1·014	3·1700	7·9251	8·5125	0·1831	105·943	3·924
157·4800	13·12333	4·374444	2·48548	= 4 =	1·08	1·352	4·2267	10·5668	11·3500	0·2441	141·258	5·232
196·8500	16·40117	5·468056	3·10685	= 5 =	1·35	1·691	5·2834	13·2085	14·1875	0·3051	176·572	6·540
236·2200	19·68500	6·561667	3·72822	= 6 =	1·62	2·029	6·3401	15·8502	17·0250	0·3661	211·887	7·848
275·5900	22·96583	7·655278	4·34959	= 7 =	1·89	2·368	7·3968	18·4919	19·8625	0·4272	247·201	9·156
314·9600	26·24667	8·748889	4·97096	= 8 =	2·16	2·706	8·4534	21·1336	22·7000	0·4882	282·516	10·464
354·3300	29·52750	9·842500	5·59233	= 9 =	2·43	3·043	9·5101	23·7753	25·5375	0·5492	317·830	11·771

Square.					Weight.			
Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.		Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.	Grams to Ounces Troy.
0·1550	10·764	1·196	2·471	= 1 =	15432·36	3·5274	2·20462	0·03215
0·3100	21·528	2·392	4·942	= 2 =	30864·71	7·0548	4·40924	0·06430
0·4650	32·292	3·588	7·413	= 3 =	46297·07	10·5822	6·61386	0·09645
0·6200	43·055	4·784	9·884	= 4 =	61729·43	14·1096	8·81849	0·12860
0·7750	53·819	5·980	12·355	= 5 =	77161·78	17·6370	11·02311	0·16075
0·9350	64·583	7·176	14·826	= 6 =	92594·14	21·1644	13·22773	0·19290
1·0850	75·347	8·372	17·297	= 7 =	108026·49	24·6918	15·43235	0·22505
1·2400	86·111	9·568	19·768	= 8 =	123458·85	28·2192	17·63697	0·25721
1·3950	96·874	10·764	22·2	= 9 =	138891·21	31·7466	19·84159	0·28936

The only material standard of customary length authorized by the U. S. Government is the Troughton scale, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound (5,760 grains) of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from

the British standard Troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter, and contains 7,000 grains troy.

The grain Troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois.

The British gallon = 4·54346 liters.

The British bushel = 36·3477 liters.

By the concurrent action of the principal Governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two metals were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilograms were prepared, from the other a definite number of meters. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot to the different Governments as so-called National prototype standards.

The metric system was legalized in the United States in 1866.

The International Standard Meter is derived from the Metre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogram is a mass of platinum-iridium deposited at the same place, and its weight *in vacuo* is the same as that of the Kilogramme des Archives.

The liter is equal to a cubic decimeter of water, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogram in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimeter.

Long ton: 2240 lb. avoirdupois	= 1016	kilogram.	Barrel of petroleum	= 42 gal.	= 1·59	hectoliter.
Short ton: 2000 " "	= 907·2	"	" " salt	= 280 lb.	= 127	kilogram.
Pound avoirdupois	= 453·6	grams.	" " lime	= 200 "	= 90·720	"
Flask of Mercury=76·5 lb. avoir.	= 34·7	kilograms.	" " natural cement	= 376 "	= 170·550	"
Troy ounce	= 31·104	grams.	" " Portland cement	= 400 "	= 181·440	"
Gallon	= 3·785	liters.	Gold coining value per oz. Troy	= [illegible]	= 0·0646	per gram.
			Silver " " " Troy	= [illegible]	= 0·04157	"

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, JANUARY 1, 1908.

Country.	Standard.	Unit.	Value in U. S. Gold.	Coins.
			cts.	
Argentina	Gold	Peso	96·5	Gold: argentine ($4·824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	20·3	Gold: former system—4 florins ($1·929), 8 florins ($3·858), ducat ($2·287), and 4 ducats ($9·149). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4·052) and 10 crowns ($2·026).
Belgium	Gold	Franc	19·3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	36·1	Silver: boliviano and divisions.
Brazil	Gold	Milreis	54·6	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
Canada	Gold	Dollar	100·0	
Central America				
Costa Rica	Gold	Colon	46·5	Gold: 2, 5, 10, and 20 colons ($9·307). Silver: 5, 10, 25, and 50 centimos.
British Honduras	Gold	Dollar	100·0	
Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	36·1	Silver: peso and divisions.
Chile	Gold	Peso	36·5	Gold: escudo ($1·825), doubloon ($3·650), and condor ($7·300). Silver: peso and divisions.
China	Silver	Tael*	59·4	
Colombia	Silver	Peso	36·1	Gold: condor ($9·647) and double condor. Silver: peso.
Cuba	Gold	Peso	92·6	Gold: doubloon Isabella, centem ($5·017). Alphonse ($4·823). Silver: peso.
Denmark	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Ecuador	Gold	Sucre	48·7	Gold: 10 sucres ($4·8665). Silver: sucre and divisions.
Egypt	Gold	Pound	494·3	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters.
Finland	Gold	Mark	19·3	Gold: 20 marks ($3·859), 10 marks ($1·93).
France	Gold	Franc	19·3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	23·8	Gold: 5, 10, and 20 marks.
Greece	Gold	Drachma	19·3	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas.
Haiti	Gold	Gourde	96·5	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions.
India	Gold	Pound†	486·65	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold	Lira	19·3	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire.
Japan	Gold	Yen	49·8	Gold: 5, 10, and 20 yen. Silver: 10, 20, and 50 sen.
Liberia	Gold	Dollar	100·0	
Mexico	Silver	Dollar	39·2	Gold: dollar ($0·983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Gold	Florin	40·2	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	Gold	Dollar	101·4	Gold: 2 dollars ($2·027).
Norway	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Persia	Silver	Kran	6·6	Gold: ½, 1 and 2 tomans ($3·409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold	Sol	48·7	Gold: libra ($4·8665). Silver: sol and divisions.
Portugal	Gold	Milreis	108·0	Gold: 1, 2, 5, and 10 milreis.
Russia	Gold	Ruble	51·5	Gold: imperial 15 rubles ($7·718) and ½ imperial, 7½ rubles ($3·859). Silver: ¼, ½, and 1 ruble.
Spain	Gold	Peseta	19·3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	19·3	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.
Turkey	Gold	Piaster	4·4	Gold: 25, 50, 100, 250, and 500 piasters.
United Kingdom	Gold	Pound	486·65	Gold: sovereign (pound sterling) and ½ sovereign.
Uruguay	Gold	Peso	103·4	Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	19·3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

* **Haikwan (Customs).** † *The sovereign is the standard coin of India, but the rupee ($0·324) is the money of account, current at 15 to the sovereign.*

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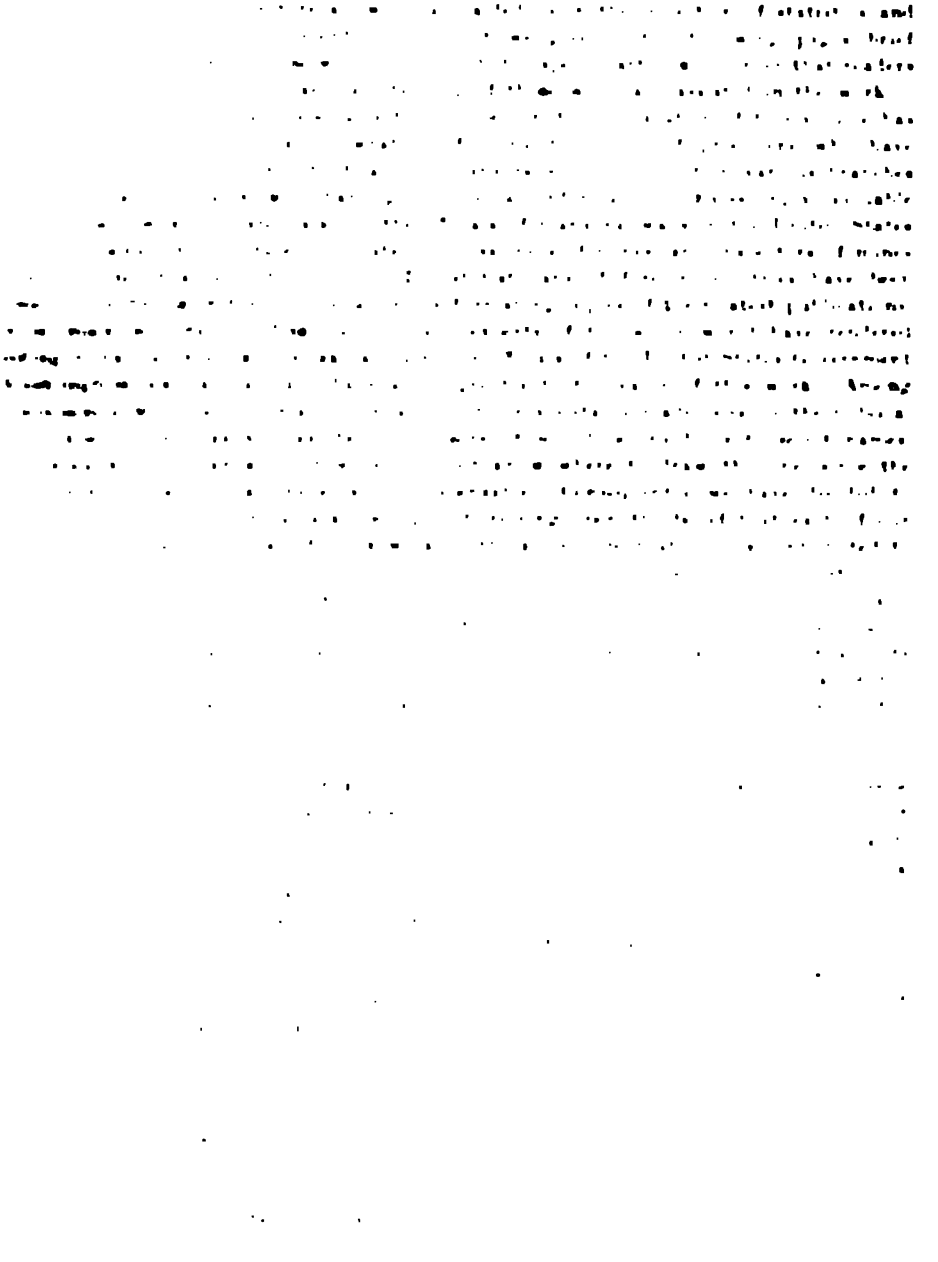

and lecturer in geology. In June, 1899, the Royal Commissioners for the exhibition of 1851 awarded him a scholarship for scientific research. Entered the Royal School of Mines, London, October of same year. Scholarship renewed for a second year to continue research under Sir William Roberts-Austen, and renewed June, 1901, for an exceptional third year to work under Prof. H. M. Howe at Columbia University. October, 1901, post-graduate work in metallurgy. Carnegie scholar of Iron and Steel Institute, May, 1902; University Fellow in Metallurgy, June, 1902; M. Sc. Durham University, June, 1903. To the present volume he contributes the paper "Progress of Metallography in 1902."

DOUGLAS, JAMES, was born in Canada, but has made his home in the United States since 1875. His first experience in mining and metallurgy was acquired in trying to unravel the complicated affairs of an unsuccessful Canadian mining enterprise. He came to the States in order to take charge of copper works established in Phœnixville, Pa., for the utilization of local copper ores, whose supply, however, proved deficient; but he is best known through his connection with the copper industry of Arizona and Northern Sonora, with which he has been intimately associated almost since its initiation. He is a past president of the American Institute of Mining Engineers and president of the Copper Queen Consolidated Mining Co., of other Arizona and Mexican concerns, including the El Paso and Southwestern Railroad and the Nacazari Railroad. Such original work as he has done was chiefly in connection with the late eminent chemist, Dr. T. Sterry Hunt, in the field of the hydrometallurgy of copper. Mr. Douglas has contributed to the present volume the notes on the copper industry in Arizona.

DOW, ALLAN W., was graduated from the course of analytical and applied chemistry of the School of Mines, Columbia College (now Columbia University), New York, N. Y., receiving the degree of Ph. B. in the year 1888. He spent one year studying in the quantitative laboratory of the university, and in 1889 accepted the position of first assistant chemist in the laboratory of the Barber Asphalt Paving Co. in New York City. This position he held until the year 1894, when he was appointed inspector of asphalt and cements for the District of Columbia by the United States Government, which position he still holds. Besides his work for the Government, he has a private practice as specialist on oils, bitumens and bituminous paving construction. He has written several articles pertaining to hydraulic cements, bitumens and bituminous paving, and to the present volume he has contributed the paper "Petroleum and Maltha Products Used in the Paving Industry."

DVORKOVITZ, PAUL, in 1877-78 was appointed sanitary chemist to the hospital of the Princess of Oldeburg in the Russo-Turkish war. Afterward he studied chemistry at the University of Moscow, and in 1883 he took the position of technical manager of an oil refinery at Baku. There he discovered a method of utilizing the soda and acid by-products obtained in course of refining, and invented a special still for continuous distillation. Later, in England, Mr. Dvorkovitz worked to develop the use of solar oil for enriching water gas, and invented an apparatus for gasifying oil and producing aromatic hydrocarbons. Five years ago he built for the Mineral Oils Corporation in London the first refinery in England, and prepared all the plans for another large refinery erected by the Shell Transport & Trading Co., Ltd., in Borneo. In 1899, he started the *Petroleum Review*. In August, 1900, Mr. Dvorkovitz was instrumental in forming the petroleum congress in Paris, which resulted in the establishing of a permanent commission for organizing international petroleum congresses every two years in the future, with a central committee in Paris, and local committees all over the world. In 1901 he founded the Petroleum Institute in London. Mr. Dvorkovitz contributes to this volume the paper, "Petroleum in Foreign Countries during 1902."

ECKEL, EDWIN C., was graduated from the School of Civil Engineering, New York University, in 1896, and supplemented his college work with a post-graduate course in geology under Prof. J. J. Stevenson. In 1899 he became connected with the New York State Museum, receiving an appointment as Assistant in Geology in 1900. While holding this position, Mr. Eckel published reports on the cements of New York State, on the quarry

connected with the United States Weather Bureau, serving as observer at Cleveland and St. Louis, and as Forecast Official in St. Louis and San Francisco. In January, 1899, he was appointed professor of meteorology in the Weather Bureau, which position he shortly afterward resigned to accept a position as assistant to the general manager of the Philadelphia Company, at Pittsburg, Pa., which position he has held for the past four years. Mr. Hammon contributes to this volume the paper "The Natural Gas Industry of the United States during 1902."

HOBART, FREDERICK, A. M., was graduated from the College of the City of New Y and served in the United States Army. He has been connected with the Jersey Locomotive Works, the Bullock Ore-dressing Machine Co., Jersey City; the Wri Machine Works, Newark, N. J.; the Camden & Amboy Railroad, and the Grant Locomo Works, Paterson, N. J., and has been assistant editor of the *Railroad Gazette*, as w as contributor to various technical periodicals and the translator of "Notes on Ste Hammers, Economies in the Combustion of Fuel," and other technical works. Si 1893, Mr. Hobart has been an associate editor of the *Engineering and Mining Jour* from the death of Mr. R. P. Rothwell, on April 17, 1901, until the appointment of David T. Day, and from the period of Dr. Day's resignation until the close of 1 he had entire charge of the conduct of the paper. Mr. Hobart acted as associate ed of THE MINERAL INDUSTRY, Volumes III. and IV., and to the present volume he c tributes the paper on "Iron and Steel," and the reviews of the various metal markets.

HOFMAN, H. O., was born in 1852 at Heidelberg, Germany. He studied at the Berg akademie at Clausthal, where he graduated in 1877 in mining engineering and metallurgy. He was then appointed chemist and assistant at the smelting and refining works at Lautenthal in the Harz. In 1881 he came to the United States and was employed successively at Mine La Motte, in Missouri, at the Argentine smelting and refining works of the Consolidated Kansas City Smelting & Refining Co., and as metallurgist of the Delaware Lead Co., in Philadelphia. When the last named works were closed he went to Colorado, and after running the Rico smeltery for a short time went to Park City, Utah, to study the amalgamation and lixiviation of silver ores at the Ontario mill. After a short time spent in charge of a smeltery in Mexico he was appointed assistant to Prof. Richards at the Massachusetts Institute of Technology in Boston; from th he went to the School of Mines of South Dakota as professor of metallurgy and assayi where he remained until called back to the Massachusetts Institute of Technology to professorship of metallurgy, which he now holds. Dr. Hofman has made numerous c tributions to technical literature, his most important work being the admirable treat on *The Metallurgy of Lead*. For his paper on the "Dry Assay of Tin Ores" the deg of Ph.D. was conferred on him by the University of Ohio. To the present volume he contributed the article, "Recent Improvements in Lead Smelting."

HUDDLE, W. J., born in Attica, Ind., in 1878, was graduated from the course of ch istry at Indiana University in 1901, receiving the degree of M.A. in 1903. In 19 he was engaged by the Western Storage Battery Co., Indianapolis, Ind. From 1902 1903 he has been a member of the staff in chemistry at the University of Wisconsin. M Huddle is at present chemist in charge of the by-products recovery plant of the Weste Gas Construction Co., Fort Wayne, Ind. To the present volume he contributes the review on "Rare Elements."

INGALLS, WALTER RENTON, was born at Lynn, Mass., in 1865, and was graduated from the Massachusetts Institute of Technology, in 1886. In 1886-90 he was engaged in mining at Leadville and elsewhere in Colorado. In 1890-92 he was assistant editor of the *Engineering and Mining Journal*, resigning that position to go to Mexico to open tin mines in the State of Durango for the Pittsburg & Mexican Tin Mining Co. In 1893 and 1894 he established himself in New York, and visited professionally various mining districts in the United States, Canada, Belgium, Germany and Poland, devoting himself especially to the metallurgy of zinc. During a part of 1894 he had charge of the operations of the Illinois Phosphate Co., in Florida, and later in the year became connected

CHARLES H. FULTON.

SAMUEL S. FOWLER.

WILLIAM H. HAMMO

HENRY O. HOFMAN.

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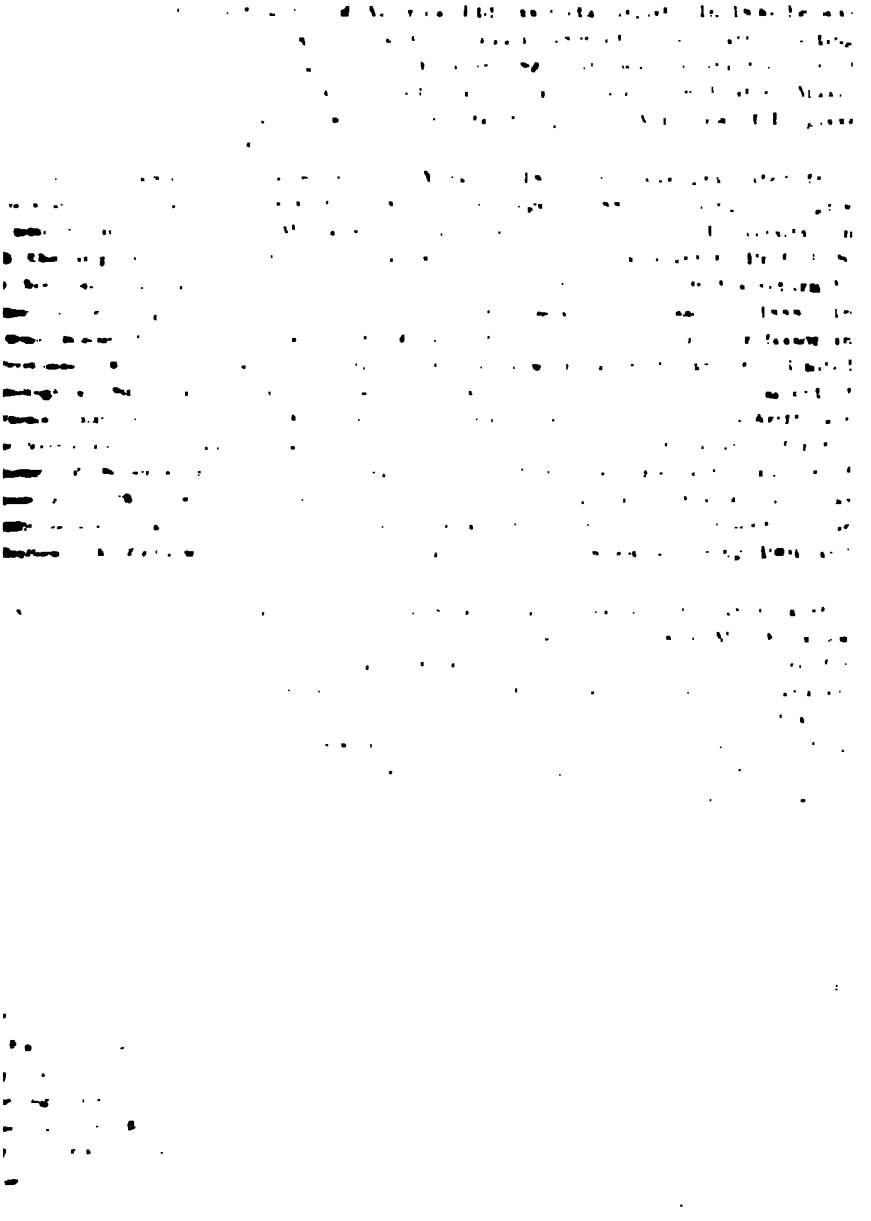

he was graduated in mining from the Associate Royal School of Mines. He then went to Mexico as assistant mining and mechanical engineer for the Michoacan Railway & Mining Co. In 1892 he was engaged by the Consolidated Kansas City Smelting and Refining Co. as mining engineer and ore purchasing agent, becoming assistant manager in 1897. Later he became manager of the mining department in Mexico of the American Smelting & Refining Co. Since 1902 he has been engaged in a general consulting business, acting as engineer for several mines in New Mexico and Mexico, and is at present secretary of the Esmeralda Mining Co. of Santa Eulalia, Chihuahua. He has contributed papers to the transactions of the Institution of Civil Engineers and the American Institute of Mining Engineers. To the present volume he contributes notes on gold, silver, lead and copper mining in Mexico.

MATHEWS, JOHN ALEXANDER, was born in Washington, Pa., May 20, 1872, and was graduated from Washington and Jefferson College in 1893 with the degree of B.Sc. Later he entered Columbia University as a graduate student in chemistry, and received therefrom the degrees of M.A. and Ph.D. He was awarded by Columbia University the University Fellowship in Chemistry in 1897, and the Barnard Fellowship for the Encouragement of Scientific Research in 1900, 1901 and 1902, by the Iron and Steel Institute of Great Britain, the Andrew Carnegie Research Scholarship in 1901, and the honorary degree of Sc. D. from Washington and Jefferson College in 1902. From 1897 to 1900 Dr. Mathews was instructor in the department of chemistry of Columbia University. He resigned in 1900 to follow research work on alloys in the laboratory of the late Prof. Sir William C. Roberts-Austen, London, which has since been continued at Columbia University under Prof. Henry M. Howe. President McKinley appointed Dr. Mathews a member of the United States Assay Commission in 1900, and the first Andrew Carnegie gold medal for research was awarded him by the Iron and Steel Institute in 1902. Dr. Mathews is a member of several societies, and is on the committee for testing the magnetic properties of iron and steel of the American Society for Testing Materials. He has written many scientific articles, and to the present volume he has contributed the paper "Alloy Steels."

MCILHINEY, PARKER C., was born in 1870, at Jersey City, N. J., and in 1892 he was graduated from the School of Mines, Columbia College, in the course of chemistry, receiving in 1894 the degree of Ph.D. for special work in chemistry and physics. From 1894 until 1900 he was connected with the departments of chemistry and metallurgy, Columbia University, and, in addition to general chemical practice he has given considerable time to the manufacture of glass, metal, enamel and pottery art works. Dr. McIlhiney contributes to this volume the paper, "Progress in the Manufacture of White Lead during 1902."

MCKENNA, CHARLES F., was born in New York in 1861, and was educated in arts at St. Francis Xavier College and in science at the School of Mines, Columbia College (now Columbia University), receiving the degree of Ph.B. from the latter institution in 1883, and of Ph.D. in 1894. He is consulting chemist to the Municipal Explosives Commission of New York City, a member of several societies abroad and at home, and is engaged in a general consulting practice. To the present volume Dr. McKenna contributes the review of "The Cement Industry in the United States during 1902."

MEMMINGER, C. GUSTAVUS, was born at Charleston, S. C., in 1864, and began work as mining engineer in the phosphate industry of South Carolina. He took an active part in the mineral development of the South, and when the Florida phosphate deposits were opened he was prominent in the furthering of the new industry there. After building and successfully operating the largest pebble phosphate mining plant in Florida, Mr. Memminger, in 1900, moved to Nashville, Tenn., from whence he removed to Florida in 1901, and is at present actively engaged in the development and mining of phosphates. Mr. Memminger contributes to this volume the paper, "Phosphate Mining Industry of the United States during 1902."

of its kind in an educational institution, has been developed to a high degree of excellence, and has been a model for similar laboratories in other colleges. In addition to his professional duties, Prof. Richards has been actively engaged as a consulting engineer in mining and metallurgical work, and has been the inventor of several ingenious devices, which have found extended use in practice. He has contributed many valuable papers to the technical press, and to the transactions of various scientific societies. His most recent work on the principles of ore dressing is the admiration of the entire body of engineers engaged in that business. To this, as in previous volumes, he has contributed the reviews, "Reviews of the Literature on Ore Dressing in 1902," and "Progress in Gold Mining during 1902."

RICKARD, THOMAS A., was born in 1864, at Pertusola, Italy, and spent his boyhood in Italy, Switzerland and Russia (the Urals). Educated in Russia and in England, he graduated from the Royal School of Mines in 1885 and immediately afterward went to Colorado. In 1887 he was appointed superintendent of the Union Mine at San Andreas, Cal. In July, 1889, he went to Australia, and for two years visited and studied most of the important mining districts of New Zealand, Queensland, New South Wales, Victoria and Tasmania. In 1891 Mr. Rickard was manager of mines near Allemont, in the Isère, France. During 1892 he returned to Colorado and began general practice as consulting engineer and during the next five years examined mines throughout the West; in 1[illegible] he was appointed State geologist of Colorado holding this honorary office for three successive terms, covering six years. In 1897 he examined a number of mines in British Columbia and Western Australia for a London financial house and in 1899 became consulting engineer to several important mines in Colorado. On January 1, 1903, Mr. Rickard became editor of the *Engineering and Mining Journal*, to which he had been for many years a frequent contributor. He has contributed largely to technical literature, especially the *Transactions of the American Institute of Mining Engineers*, the *Institution of Mining and Metallurgy* and the publications of other technical societies. He is also the author of *The Stamp Milling of Gold Ores*, published in 1897. To the present volume he contributes the article "The Sampling and Estimation of Ore in a Mine."

RIES, HEINRICH, Ph.B., A.M., Ph.D., was graduated in 1892 from the School of Mines, Columbia College (now Columbia University), New York City. After his graduation he was employed as assistant geologist on the New York State Geological Survey, and during the World's Fair at Chicago he was assistant director of the New York scientific exhibit. From 1893 to 1895 he held the University Fellowship in Mineralogy at Columbia University, and was awarded the Barnard Fellowship for scientific research by the same institution from 1897 to 1900. In 1898 he was appointed Assistant Professor of Economic Geology at Cornell University, Ithaca, N. Y. Dr. Ries has made a special study of the economic geology of clays, has made extensive investigations of both domestic and foreign deposits, and since 1895 has acted as clay specialist for the United States Geological Survey. He has prepared special reports on the clays of New York, Michigan, North Carolina, Alabama, Louisiana, Maryland and New Jersey. In 1895 he was judge of clays at the Cotton States Exposition, and a member of the jury of awards at the Pan-American Exposition at Buffalo, N. Y. To the present volume Dr. Ries contributes the paper, "Review of the Literature of Clays and Clay Products in 1902."

ROSSI, AUGUSTE J., was born in Paris in 1839. In 1855 he was graduated from the University of France, receiving the degree of B.A. and B.S. and in 1859 received the degree of civil and mining engineer from the Ecole Centrale of Arts and Manufactures of Paris. Soon afterward he came to the United States, of which he has long been an adopted citizen. Mr. Rossi, in the course of his professional practice, has been with the Morris & Essex Railroad, with the Boonton blast furnaces and with the New York Ice Machine Co. For the past eight years he has devoted himself particularly to electrometallurgy, and as consulting mining engineer has been engaged in the study of the metallurgy of titanium. He is a member of the American Institute of Mining Engineers, the American Chemical Society and of the American Electro-Chemical Society, and various articles from his pen

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ULKE, TITUS, was born in 1866, at Washington, D. C. In 1889 he was graduated from the Royal School of Mines at Freiberg, Saxony, as metallurgical engineer. After spending some time in visiting the various mines and metallurgical works in Europe, Mr. Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Co., in South Dakota. In 1891 he became assayer for the United Smelting Co., and afterwards was engaged by the Anaconda Mining Co., as chemist at its electrolytic copper refining works. In 1893 Mr. Ulke acted as metallurgist to the Mines and Mining Department of the Chicago Columbian Fair, and was later employed at the Guggenheim works at Perth Amboy, N. J. As triangulator for the U. S. Geological Survey in 1897, he had charge of a party to survey the Montana timber reserves. Soon after the declaration of war with Spain, Mr. Ulke was appointed Assistant Inspector of Ordnance, U. S. A., and in 1900 he became metallurgical engineer to the Lake Superior Power Co., Sault Ste. Marie, Ont. He is now connected with the Ordnance Department at Watervliet Arsenal, N. Y. Mr. Ulke has contributed to the present volume the reviews of "Progress in the Electrolytic Refining of Copper" and "Progress in the Metallurgy of Nickel in 1902."

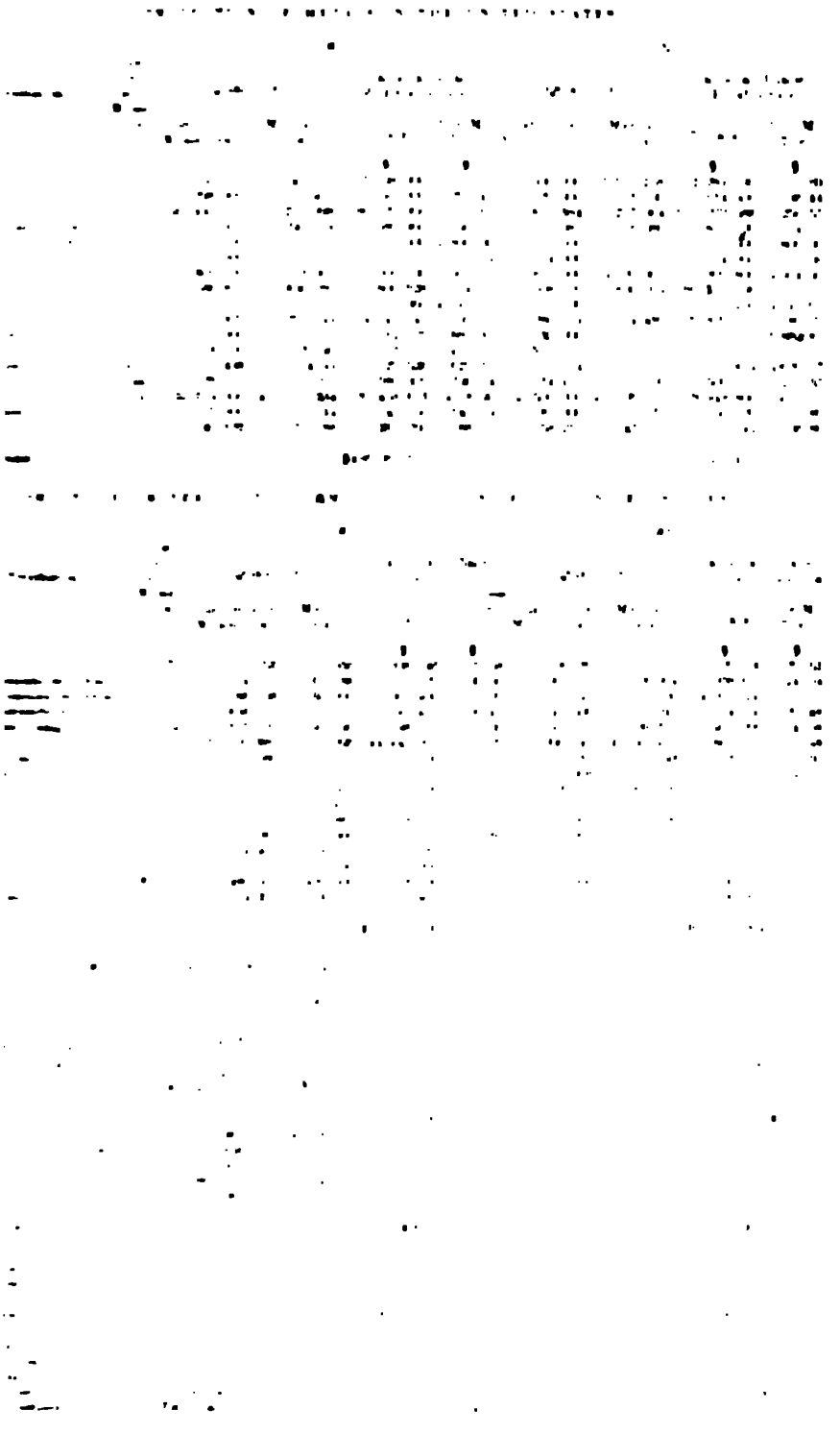
WEED, WALTER HARVEY, was born in St. Louis, Mo., May 1, 1862, and was graduated in 1883 from Columbia College School of Mines in the course of mining engineering. Mr. Weed was appointed assistant geologist U. S. Geological Survey in June, 1883; in 1884 discovered the vegetable origin of the siliceous sinter of Yellowstone; and the following year discovered and described Death Gulch, Yellowstone Park. Following his specialty of economic and applied geology, Mr. Weed has investigated and reported on various coal, gold and silver districts of Montana, and has made careful studies of the copper and gold regions of Virginia and the Carolinas, Cripple Creek district, and others in Colorado, Arizona, California, Wyoming and Mexico. To the present volume Mr. Weed contributes notes on copper, gold and silver mining in Montana.

INTRODUCTION

especially those of Alabama, Kansas, Iowa and Indiana, and the State mining bureaus of California and Colorado. We have generally credited these figures to the proper sources in the subsequent pages, but this acknowledgment may stand for any unintentional oversights.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES. (FIRST PRODUCTS.)

Number.	Products.	Customary Measures.	1901. Quantity. Customary Measures.	1901. Quantity. Metric Tons.	1901. Value at Place of Production. a Totals.	1901. Value at Place of Production. a Per M. Ton.	1902. Quantity. Customary Measures.	1902. Quantity. Metric Tons.	1902. Value at Place of Production. a Totals.	1902. Value at Place of Production. a Pr. M. Ton.
					$	$			$	$
1	Asbestos	Sh. T.	747	678	13,498	19·91	1,010	916	12,400	13·54
2	Asphaltum	Sh. T.	20,416	18,521	387,859	18·21	29,903	27,128	389,602	14·36
3	Asphaltic limestone	Sh. T.	6,970	6,325	33,375	5·28	1,859	1,686	7,782	4·62
4	Bitumin's sandstone	Sh. T.	34,248	31,078	138,601	4·46	57,837	52,469	157,093	2·99
5	Barytes	Sh. T.	49,070	44,528	157,844	3·54	58,149	52,752	186,713	3·54
6	Bauxite	L. T.	18,905	19,214	79,914	4·16	27,322	27,759	121,465	4·38
7	Bismuth ore	Sh. T.	310	289	25,488	88·19	37	34	2,960	87·06
8	Bromine	Lb.	552,028	250	149,045	596·18	513,913	233	128,472	551·39
9	Calcium borate. c	Sh. T.	23,231	21,075	1,012,118	48·02	17,202	15,605	2,434,994	156·03
10	Cement, nat. hydraul. g	Bbls.	7,084,823	963,921	3,056,278	3·17	9,083,759	1,236,110	4,087,692	3·31
11	Cement, Portland	Bbls.	12,711,225	2,306,756	12,532,360	5·43	16,535,000	3,000,000	16,637,500	5·54
12	Chrome ore	L. T.	498	506	7,740	15·29	315	320	4,725	14·77
13	Clay products				110,211,587				e100,000,000	
14	Coal, anthracite	Sh. T.	67,538,536	61,270,558	112,704,055	1·84	41,451,267	37,604,343	83,002,229	2·20
15	Coal, bituminous	Sh. T.	225,759,980	204,808,110	236,305,214	1·15	258,371,987	234,398,529	285,574,339	1·11
16	Coal, cannel	Sh. T.	(ff)				(ff)			
17	Cobalt oxide	Lb.	13,860	k 6,062	24,048	k 3·97	Nil.			
18	Copper sulphate. f	Lb.	78,004,257	35,282	m 3,674,000	90·38	48,763,538	22,119	2,028,563	91·71
19	Corundum	Sh. T.	4,305	3,906	146,040	37·40			95,135	
20	Emery	Sh. T.								
21	Feldspar	L. T.	31,019	31,517	220,422	6·99	(gg)			
22	Fluorspar	Sh. T.	19,586	17,773	113,803	6·40	27,127	27,561	143,520	5·19
23	Fullers earth	Sh. T.	14,112	12,802	96,835	7·57	14,100	12,791	109,980	8·56
24	Garnet	Sh. T.	4,444	4,033	158,100	39·20	3,722	3,376	88,270	26·15
25	Gilsonite	Sh. T.	1,500	1,653	46,000	27·82	4,052	3,676	61,182	16·64
26	Graphite, crystalline	Lb.	3,967,612	k 1,800,187	135,914	k 0·08	4,176,824	1,895	153,147	80·80
27	Graphite, amorphous	Sh. T.	809	734	31,800	43·32	4,739	4,299	55,964	12·01
28	Gypsum	Sh. T.	659,659	598,602	1,577,493	2·64				
29	Iron ore	L. T.	27,897,479	28,333,079	47,408,714	1·67	34,636,121	35,190,299	64,769,546	1·84
30	Lepidolite	Sh. T.	e 110	100	4,070	40·66	(gg)			
31	Magnesite. c	Sh. T.	13,172	11,949	43,057	3·60	3,466	3,144	21,302	6·79
32	Manganese ore. i	L. T.	638,795	649,016	1,644,117	2·53	(gg)			
33	Mica, scrap	Sh. T.	2,165	1,964	19,719	10·04	(gg)			
34	Mica, sheet	Lb.	360,000	k 163,322	98,859	k 0·61	(gg)			
35	Molybdenum ore	Sh. T.	15	15	750	5·14	15	15	750	5·14
36	Monazite	Lb.	748,736	340	59,262	174·30	(gg)			
37	Natural gas				27,067,500				e 30,000,000	
38	Ocher. p	Sh. T.	43,036	39,042	n 516,308	13·48	55,320	50,186	705,026	14·05
39	Petroleum, crude	gBbls.	69,380,194	8,889,263	66,417,335	7·51	84,250,738	12,174,961	70,628,100	5·80
40	Phosphate rock	L. T.	1,488,723	1,507,463	5,316,403	3·53	1,464,668	1,488,103	4,636,516	3·12
41	Precious stones				289,050				318,300	
42	Pyrites	L. T.	234,825	238,661	1,024,449	4·29	228,198	231,849	971,796	4·19
43	Salt. q	Bbls.	20,566,661	2,613,299	6,617,449	2·53	23,849,221	3,029,022	5,668,036	1·87
44	Silica, brick	M.	55,000		1,018,050		e 60,000		e 1,200,000	
45	Diatom. earth	Sh. T.	dd 4,020	3,647	52,950	14·52	4,855	4,404	49,974	11·33
46	Quartz	Sh. T.	11,050	12,476	41,500	3·26	13,904	12,614	117,423	9·13
47	Sand, etc	L. T.	e 900,000	914,400	e 1,373,912	1·48	e 1,000,000	1,016,000	e 1,500,000	1·45
48	Pumice	Sh. T.	Nil.				100	91	500	5·49
49	Grindstones	Sh. T.	bb 16,807	15,247	580,703				656,882	
50	Whetstones				158,300				219,172	
51	Tripoli	Sh. T.	(ee)				(ee)			
52	Slate, roofing	Sq'es.	1,304,379	394,072	4,114,410	j 3·15	(gg)			
53	Manufactures				6,3.115		(gg)			
54	Pigment	Sh. T.	4,865	4,413	41,211	9·34	(gg)			
55	Soapstone	Sh. T.	(cc)				(cc)			
56	Soda, natural. r	Sh. T.	15,000	13,608	197,000	14·48	16,000	14,515	208,000	14·33
57	Stone, for building				55,615,926		(gg)			
58	Stone, limestone (flux)	L. T.	8,540,108	8,679,656	4,659,836	0·54	9,490,090	9,644,931	5,504,358	0·59
59	Stone, lithographic	Sh. T.	Nil.				(gg)			
60	Sulphur	L. T.	6,976	7,088	223,430	31·52	7,448	7,562	230,560	30·08
61	Sulphuric acid. f. l	Sh. T.	98,000	88,905	m 2,293,200	25·75	(gg)			
62	Talc, common	Sh. T.	28,043	25,984	424,888	16·35	21,640	19,632	413,497	21·06
63	Talc, fibrous	Sh. T.	69,200	62,778	493,600	7·69	71,100	64,501	615,360	9·54
64	Tungsten ore	L. T.	160	162	27,729	171·11	221	224	38,600	172·32
65	Uranium ore	Sh. T.	375	340	102,500	301·47	810	735		
66	Zinc sulphate	Sh. T.	7,500	6,804	322,425	47·39	(gg)			
67	Zinc ore, exported	Sh. T.	44,156	40,058	1,167,684	29·15	54,613	49,582	1,449,104	29·23
68	Zinc white. s	Sh. T.	46,500	42,185	3,720,000	88·18	52,780	46,929	4,023,399	85·73
69	Zinc-lead	Sh. T.	2,500	2,268	150,000	66·14	4,000	3,629	225,000	62·00
70	Est. prod. unspecified				5,000,000				63,915,000	
	Totals				721,938,333				758,389,378	



of 300 lb. (*h*) Barrels of 400 lb. (*i*) Includes manganiferous iron ore; this is not duplicated in the report of iron ore. (*j*) Value per square, i.e., 100 sq. ft., lapped and laid; the weights are calculated on the basis 3 squares=2,000 lb., but these figures are only approximately correct. (*k*) Kilograms or per kilogram. (*l*) Reduced to a basis of 60° B. (*m*) Average market price at New York. (*n*) Nominal. (*o*) Value before grinding. (*p*) Includes ocher, umber, sienna, and oxide of iron. (*q*) Includes salt used for the manufacture of alkali; the barrel of salt weighs 280 lb. (*r*) Reduced to a basis of 5% ash. (*s*) Includes a small amount made from spelter. (*t*) Average value of Lake copper at New York, less 0·25c. per lb. (*u*) Includes spiegeleisen, though the total value is reckoned as if the whole product were ferromanganese. (*v*) Average market price at Pittsburg. (*w*) Troy oz. (*x*) Flasks of 76·5 lb. (*y*) Barrels of 42 gal. (*z*) Includes a comparatively small amount made directly from ores. (*aa*) Not included in the preceding tables. (*bb*) Does not include 40,980 pieces of unspecified weight; the value, however, is included in the total. (*cc*) Included with common talc. (*dd*) Includes tripoli. (*ee*) Included with diatomaceous earth. (*ff*) Included with bituminous. (*gg*) Statistics not collected.

Abbreviations: Sh. T., short tons (2,000 lb.); L. T., long tons (2,240 lb.); M. T., metric tons (2,204 lb.).

METALS AND ALLOYS.

Aluminum.—The production of aluminum in the United States in 1902 was 7,300,000 lb. ($2,284,590), as compared with 7,150,000 lb. ($2,238,000) in 1901.

Antimony.—The production of antimony in the United States in 1902 was 7,122,000 lb. ($634,506) as compared with 5,298,000 lb. ($542,020) in 1901.

Copper.—The production increased from 597,443,212 lb. ($86,629,266) to 610,815,384 lb. ($71,072,586) in 1902. The main increases were in Montana, Michigan, Utah and the Southern States. California and Arizonia reported decreases. In addition to the domestic copper produced in 1902, there were 85,000,000 lb. derived from foreign sources.

Ferromanganese.—The production of ferromanganese, including spiegeleisen, was 212,981 long tons ($13,852,199), as compared with 291,461 long tons ($16,589,960) in 1901.

Ferromolybdenum.—The production in 1902 is estimated at 16,000 lb. ($19,600), as compared with the same totals in 1901.

Gold and Silver.—The domestic production of gold in 1902 was 3,870,000 troy oz. ($79,992,800), as compared with 3,805,500 troy oz. ($78,666,700) in 1901. The production of silver was 55,500,000 troy oz. ($28,948,800), as compared with 55,214,000 troy oz. ($32,458,653). There was a slight increase in the production of gold in Colorado; and Alaska, Arizona and South Dakota also contributed to the enlarged production. Besides the production reported, 1,689,991 oz. of gold and 48,087,244 oz. of silver were smelted in the United States from imported ores. The average value of silver in the United States in 1902 was 52·16c. per oz., against 58·95c. per oz. in 1901.

Iron.—The production of pig iron in 1902, exclusive of ferromanganese and spiegeleisen, was 17,608,326 long tons ($289,304,796), as compared with 15,586,893 long tons ($232,800,328) in 1901. Of the production in 1902 10,393,168 long tons were Bessemer pig iron against 9,546,793 long tons in 1901. The production of basic pig was 2,438,590 long tons, against 1,448,850 long tons. The remainder of the output is classed as foundry and forge iron.

Lead.—The domestic production in 1902 was 280,524 short tons ($22,829,043), against 279,922 short tons ($24,241,245) in 1901. There was a large increase in the output of the Idaho mines. The average price of lead at New York in 1902 was 4·069c., against 4·33c. per lb. in 1901. Besides the above, the American smelters in 1902 recovered 34,922 tons of lead from foreign ore and base bullion, against 22,260 in 1901.

Molybdenum.—Some 35,000 lb. of molybdenum ($62,125) were produced in

Bauxite.—The production in 1902 was 27,322 long tons ($121,465), as compared with 18,905 long tons ($79,914) in 1901.

Bromine.—The production in 1902 was 513,913 lb. ($128,472), against 552,023 lb. ($149,045) in 1901. These figures include the bromine equivalent of potassium bromide, which is produced in Michigan.

Calcium Borate.—The production in 1902 was 17,202 short tons, as compared with 23,231 short tons in 1900. Most of the product is obtained from colemanite, which is mined in California. The value of the production in 1902 was $2,434,994, against $1,012,118 in 1901.

Carborundum.—The production reported by the sole producer was 3,741,500 lb. ($374,150) in 1902, as compared with 3,838,175 lb. ($345,435) in 1901.

Cement.—The total production of Portland cement in 1902 was 16,535,000 bbl. of 400 lb., valued at $16,637,500, as compared with 12,711,225 bbl. ($12,532,360) in 1901. The Lehigh district of Pennsylvania and New Jersey has maintained its supremacy as a center of production, and Michigan and other States also showed important gains. Aside from the remarkable increase in production, the year 1902 was notable for the very low prices commanded by cement in the Eastern markets. The production of natural rock cement in 1902 was 9,083,759 bbl. of 300 lb., valued at $4,087,692, as compared with 7,084,823 bbl. ($3,056,278) in 1901. As in previous years, the Kentucky-Indiana district and Ulster County, N. Y., were the largest producers. The production of slag cement in 1902 was 547,175 bbl. of 400 lb., valued at $465,099, against 272,689 bbl. ($198,151) in 1901.

Chrome Ore.—The production in 1902 was 315 long tons ($4,725), against 498 long tons ($7,740) in 1901. The entire production in 1901 and 1902 was mined in California.

Clay.—The value of brick and other clay products made in the United States in 1901 was $110,211,587, as compared with $78,704,678 in the previous year.

Coal and Coke.—The total production of coal in the United States in 1902 was 299,823,254 short tons ($368,576,568), as compared with 293,298,516 short tons ($349,009,269) in 1901. The production of anthracite, all of it from Pennsylvania, with the exception of small amounts from Colorado and New Mexico, was 41,451,267 short tons ($83,002,229) in 1902, as compared with 67,538,536 short tons ($112,704,055) in 1901. Kentucky's production of cannel coal is included under the production of bituminous. The output of bituminous coal, of which Pennsylvania and the Central States are the largest producers, was 258,371,987 short tons ($285,574,339) in 1902, as compared with 225,759,980 ($236,305,214) in 1901. There was an increase in the output of most of the important coal producing States in 1902. The total production of coke in 1902 was 23,090,342 short tons ($51,864,575), as compared with 21,795,883 short tons ($44,445,923) in 1901. Pennsylvania furnished about two-thirds of the output each year.

Cobalt Oxide.—There was no production of cobalt oxide in 1902, against 13,360 lb. ($24,048) in 1901.

Copperas.—The production in 1902 was 19,784 short tons ($118,474), as compared with 23,586 short tons ($112,366) in 1901. The chief producer in this

country is the United States Steel Corporation, which controls all the wire and rod works recovering copperas as a by-product. The above statistics do not include copperas converted into Venetian and Indian reds at the works of original production.

Copper Sulphate.—The production in 1902 was 48,763,538 lb., as compared with 78,004,257 lb. in 1901. Of this the amount recovered as a by-product chiefly by gold and silver refiners, was 35,879,212 lb. in 1902, and 51,000,000 lb. in 1901. The remainder of the output each year was made from metallic copper and from ore, the former being included in the production of copper. The average value of copper sulphate at New York per 100 lb. was $4·16 in 1902, as compared with $4·10 in 1901.

Corundum and Emery.—The production of corundum and emery in 1902 was valued at $95,135, as compared with 4,305 short tons ($146,040) in 1901. The production of steel emery or crushed steel in 1902 was 735,000 lb. ($51,450), against 690,000 lb. ($37,950) in 1901, the entire product each year being supplied by a single concern—the Pittsburg Crushed Steel Co.

Feldspar.—The production in 1901 was 31,019 long tons, valued at $220,422. The statistics for 1902 are not yet available. Pennsylvania, Massachusetts and New York are the principal producers of feldspar.

Fluorspar.—The production in 1902 was 27,127 short tons ($143,520), as compared with 19,586 short tons ($113,803) in 1901, Illinois, Kentucky and Tennessee furnishing the entire output.

Fullers Earth.—The output in 1902 was 14,100 short tons ($109,980), as compared with 14,112 short tons ($96,835) in 1901.

Garnet.—The production in 1902 was 3,722 short tons ($88,270), as compared with 4,444 short tons ($158,100) in 1901, the output each year being furnished by New York, Pennsylvania and Connecticut. The domestic resources of this mineral are large, but the demand for it is limited.

Graphite.—The production of crystalline graphite in 1902 was 4,176,824 lb. ($153,147), as compared with 3,967,612 lb. ($135,914) in 1901. The production of amorphous graphite in 1902 was 4,739 short tons ($55,964), as compared with 809 short tons ($31,800) in 1901. As in previous years, the larger part of the crystalline product in 1902 was obtained from Ticonderoga, N. Y., although a considerable quantity was mined in Pennsylvania and in Clay County, Alabama. The single producer of artificial graphite reported an output of 2,358,828 lb. ($110,700), as compared with 2,500,000 lb. ($119,000) in 1901.

Gypsum.—The production of gypsum in 1901 was 659, 659 short tons, valued at $1,577,493. These figures represent the amount of crude rock quarried. The larger part of the production is marketed in the form of stucco, or plaster of Paris.

Iron Ore.—The production in 1902 was 34,636,121 long tons, as compared with 27,887,479 long tons in 1901, these figures being exclusive of the production of manganiferous iron ore reported separately under manganese. The increase in the production was due chiefly to the Lake Superior ranges, which furnished by far the greater part of the output.

Lead White, Red Lead and Litharge.—The production of white lead in 1902

was 114,658 short tons ($11,978,172), as compared with 100,787 short tons ($11,252,653) in 1901; of red lead, 11,669 ($1,262,712), as compared with 13,103 ($1,448,550); of litharge, 12,755 ($1,299,443), as compared with 9,460 ($979,586); of orange mineral, 867 ($138,349), as compared with 1,087 ($224,667) in 1901. The larger part of these products is obtained by the corrosion of pig lead, but a small part of the white lead product is made directly from the ores.

Limestone for Iron Flux.—Iron smelters consumed 9,490,090 long tons of limestone in 1902, as compared with 8,540,168 long tons in 1901, the increase being caused by the greater production of pig iron.

Magnesite.—The production in 1902 was 3,466 short tons ($21,362), as compared with 13,172 short tons ($43,057) in 1901. The entire output in both years was mined in California and represented but a small portion of the magnesite consumed in this country. Large quantities of this mineral are imported from Austria and Greece.

Manganese Ore.—The production of manganese ore, including manganiferous iron ore in 1901 was 638,795 long tons.

Mica.—The production of sheet mica in 1901 was 360,060 lb. ($98,859) of scrap mica, 2,165 short tons ($19,719). Mica is mined in South Dakota, New Hampshire, North Carolina and Nevada. The imports of mica into the United States in 1902 were 2,251,856 lb., valued at $466,332, of which 102,299 lb. ($46,970) was cut or trimmed mica.

Mineral Wool.—The production in 1902 was 10,843 short tons ($105,814), as compared with 6,272 short tons ($68,992) in 1901. A part of this product was made from slag and a part by the fusion of natural rock, the latter being the more valuable.

Molybdenum Ore.—The production in 1902 is estimated at 15 short tons, valued at $750, as compared with a like output in 1901. The value of molybdenum ore varies within wide limits, and a nominal value of $50 per ton is placed upon the output.

Monazite.—The output in 1901 was 748,736 lb. ($59,262), and came from North Carolina and South Carolina.

Natural Gas.—The production of natural gas in 1902 is estimated at $30,000,000, as compared with a value of $27,067,500 in 1901.

Ocher and Oxide of Iron Pigments.—The production of ocher, umber, sienna and natural oxide of iron ground pigment, the last being known commonly as metallic paint, was 55,320 short tons ($705,026) in 1902, as compared with 43,036 short tons ($516,308) in 1901. The separation of these products is attended with considerable difficulty, as they merge into one another. Pennsylvania is the largest producer of these pigments.

Petroleum.—The total output in 1902 was 84,250,738 bbl. ($70,628,100), as compared with 69,389,194 bbl. ($66,417,335) in 1901. The large increase was due to the enormous developments in Texas and California, the Appalachian field showing a decided falling off. The average value was considerably lower in 1902 than in 1901, as the Western oil is valued upon a fuel basis.

Phosphate Rock.—The production in 1902 was 1,464,668 long tons ($4,636,-

Jersey, Pennsylvania and Maryland. The production of fibrous talc, all of it from St. Lawrence County, N. Y., was 71,100 short tons ($615,350) in 1902, as compared with 69,200 short tons ($483,600) in 1901.

Tungsten Ore.—There was a production in 1902 of 250 short tons of tungsten ore, as compared with 179 short tons in 1901. The outputs in each year were nominally valued at $38,600 and $27,720, respectively. Most of the material produced in 1902 came from Colorado.

Uranium Ore.—In 1901, Colorado produced 375 short tons of uranium ore, as compared with 810 tons in 1902.

Venetian and Indian Reds.—The production of these colors in 1902 was 11,758 short tons ($196,905), as compared with 9,201 short tons ($153,467) in 1901. These figures include only the output at works where the original copperas was made, and do not take into account any material that may have been made by second handlers.

Zinc Ore.—The quantity of zinc ore of domestic origin exported from the United States in 1902 was 54,613 short tons ($1,449,109), as compared with 44,156 short tons ($1,167,684) in 1901. Most of the ore exported was mined in New Jersey.

Zinc Sulphate.—There was a production of 7,500 short tons of zinc sulphate in 1901.

Zinc White.—The production in 1902 was 52,730 short tons, as compared with 46,500 short tons in 1901. The total value was $4,023,299, as compared with $3,720,000 in 1901. A large part of the production of zinc white in the United States is made by the New Jersey Zinc Co.

ALUMINUM AND ALUM.

which averaged $2·25 per ton; adding to this amount the duty of $1 per long ton, allowed the delivery at a cost *cx mine* of $3·30 per ton. Contrasting this cost with the freight rates from Georgia and Alabama of $3·85 per ton to Philadelphia, and $5 or more to Boston, shows that the French ore can be delivered to the seaport cities above named more cheaply than the domestic ore. On account of the high iron content of the French bauxite, its use is limited mainly for making aluminum hydrate, which is the raw material utilized for the manufacture of aluminum. There was no export of bauxite from the United States during 1902, as compared with 1,000 long tons in 1901.

Alabama and Georgia.—(By Thomas L. Watson.)—The mining of bauxite in the Southern Appalachian field during 1902 was confined principally to Georgia, a small quantity only being mined in Alabama. The principal producers of bauxite were the Republic Mining & Manufacturing Co., of Hermitage, Floyd County; the Southern Bauxite Mining & Manufacturing Co., of Cave Spring, Floyd County, and John H. Hawkins, of Rome. Several years ago the Dixie Bauxite Co. secured control of the principal properties, and it is claimed that it has 2,500,000 tons of high-grade ore blocked out. This company is awaiting the exhaustion of the other bauxite mines before contributing to the output in order to obtain a higher price for the product. The Republic Mining & Manufacturing Co. confined its operations principally to several land lots in the vicinity of Hermitage which were early exhausted, and to the Fat John bank in the Bobo district, nine miles west of Rome, which yielded a large quantity of ore. The company also mined on the Watters property, five miles north of Rome, where the ore deposit is one of the largest, if not the largest in the State; the product from this mine has been uniformly of high grade. The John H. Hawkins plant is located near McConnel's Station in Walker County, near the county line at the Armington bank. The deposit covers an area of 150×50 ft., and is stated to have an average depth of 36 ft., which is equivalent to a volume of 540,000 cu. ft.; assuming a specific gravity of 2·5 for the ore and allowing 25% loss in preparation, the deposit will yield 31,590 tons of commercial product. The mineral is mined by the open-cut method, and is carried in a side-dump car to a submerged, double log-washer, consisting of two 12-in. square logs, each carrying chilled cast iron lugs placed spirally upon them. They revolve in opposite directions 10 r. p. m. The upper end is 27 in. high, and water is here fed in by a 2·5-in. nozzle. After washing, the mineral is placed in a rotary dryer, 36 in. diameter by 36 ft. long, mounted on cast rollers 16 in. diameter, and revolved by an encircling sprocket chain. The flue end is 6 in. higher than the grate end, and wood is used for fuel. The composition of the crude bauxite averages Al_2O_3 62%, Fe_2O_3 1·5%, SiO_2 2%, and TiO_2 2%. The water is driven off by heating to redness.

On account of its freedom from iron oxide, the greater part of the bauxite produced in Alabama and Georgia is used in the manufacture of alum and aluminum sulphate, a small proportion only being utilized in the manufacture of aluminum. The first grade product is valued (f. o. b.) at $5·50, and the second grade at $4·50 per long ton.

Systematic prospecting for deposits of first grade ore was continued over the

tached cold storage room. The buildings are protected with standard fire plugs and hose well situated.

The ore is ground by a series of coarse and fine crushers and handled by elevators and conveyors from the tram cars, which bring the crude ore into the works, to the bins where it is stored ready for shipment. A large proportion of the ground ore is calcined direct, the smaller quantity being washed to remove the siliceous gangue and subsequently dried before calcination.

The new refining plant of the Pittsburg Reduction Co., three miles from East St. Louis, will occupy six acres of ground and will be similar to the works at New Kensington, Pa. It is stated that the calcining furnaces at the latter plant (eight in number) will be removed to the new works as soon as the construction is completed, probably early in 1903. During the last few years crude or calcined bauxite ore has been shipped from the mines to the New Kensington plant for the extraction of pure aluminum oxide, which was sent to Niagara Falls to be reduced to aluminum. The metal was then sent to New Kensington and rolled into sheets or drawn into wire.

The Bayer process for the purification of bauxite has been improved in various details, and now yields a better quality of aluminum oxide at a lesser cost. At the new East St. Louis refining plant the lime process, patented by Mr. Hall, will be used, and at the Niagara Falls plant an electric furnace method of purifying bauxite is in contemplation which may still further reduce the cost of manufacture of pure aluminum metal. Additional details of the processes of purification of bauxite will be found under the caption "Aluminum," given later in this section; also in previous volumes of THE MINERAL INDUSTRY.

THE WORLD'S PRODUCTION OF BAUXITE.

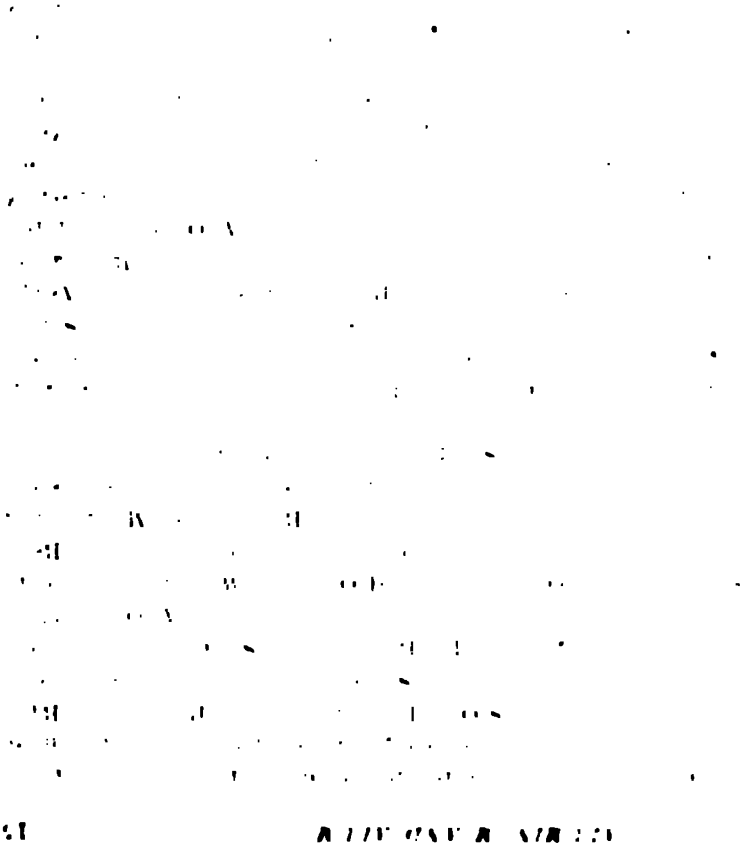
The world's supply of bauxite is derived chiefly from France, Ireland and the United States, and the annual production from 1895 to 1901, inclusive, is detailed in the subjoined table:—

PRODUCTION OF BAUXITE IN THE PRINCIPAL COUNTRIES OF THE WORLD.
(IN METRIC TONS.)

Country.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
France	17,958	33,820	41,740	36,723	48,215	58,530	76,680
United Kingdom	10,574	7,365	13,449	12,900	8,137	5,873	10,357
United States	19,101	17,370	20,919	27,220	37,402	23,556	19,207
Total	47,633	58,555	76,108	76,843	93,754	87,959	106,184

France.—The principal bauxite mines are in the south of France, between the town of Brignoles (Var) and the Department of the Hérault. Formerly the center of the industry was at the town of Baux, from which the name of bauxite was derived. In the Department of the Var there are 31 mines, the most important being at Ampus, Barjols, Cabasse, Carces, Le Cannet du Luc, Le Muy, Le Thoronet, Lorgues, Mazaugues, Meounes, Puget sur Argens, Rougiers, Tourves and Vins.

Three varieties of bauxite are produced—ferruginous, aluminous and spotted. There is but little demand for ferruginous bauxite on account of the high con-



As far as known the published analyses of the Italian bauxites have an alumina content varying from 47·4 to 58·9%. The large quantity of iron oxide present, which has not been found less than 18% Fe_2O_3, is a serious drawback to the commercial development of the mines. It must be noted, however, that a careful study of the deposits has not yet been made. The occurrence of bauxite containing from 51·13 to 57·52% Al_2O_3 is reported in the Province of Apullia in Southern Italy.

II. Corundum and Emery.

The production of corundum and emery and the imports of emery in the United States during the past four years are given in the subjoined tables:—

PRODUCTION OF CORUNDUM AND EMERY IN THE UNITED STATES.

Substance.	1899.			1900.			1901.			1902.		
	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.
Corundum	970	$78,570	$81·00	880	$58,100	$70·00	4,305	$146,040	$37·40	(c)	$95,135	.....
Emery	3,000	150,000	50·00	4,200	189,000	45·00						
Steel emery	337	47,250	140·21	345	48,300	140·00	355	49,700	140·00	368	51,450	$140·00
Total	4,237	$275,820	.....	5,375	$295,400	.....	4,660	$195,740	.....	.....	$146,585	.....

(a) The values are based on the prices at the mines, but except in the case of steel emery are of slight significance owing to the great range between the different grades of the minerals. The changes in the annual averages do not indicate fluctuations in market quotations so much as changes in the proportion of different grades of mineral in the total. (b) 2,000 lb. (c) The quantity of emery produced was 3,497 short tons.

IMPORTS OF EMERY INTO THE UNITED STATES.

Year.	Grains.		Ore or Rock.		Other M'f'rs.	Total Value.	Year.	Grains.		Ore or Rock.		Other M'f'rs.	Total Value.
	Pounds.	Value.	Long Tons.	Value.	Value.			Pounds.	Value.	Long Tons.	Value.	Value.	
1895..	678,761	$25,066	6,903	$80,396	27,586	$133,088	1899.	728,299	$39,124	7,435	$116,493	$11,514	$167,131
1896..	751,464	26,520	6,289	119,667	1,971	148,158	1900.	661,482	26,590	11,393	208,360	10,008	230,958
1897..	590,095	20,022	5,209	107,649	2,211	129,882	1901.	1,116,729	43,207	12,441	240,856	10,927	294,990
1898..	577,655	23,320	5,547	106,269	3,810	133,399	1902.	1,665,737	60,079	7,166	151,959	13,776	225,814

Progress of the Corundum and Emery Industry during 1902.

By Joseph Hyde Pratt.

There are few changes to be noted in the corundum and emery industry during 1902, and none of these is of special importance. The principal change is, perhaps, the incorporation of the Blue Corundum Mining Co., which now owns mines at Chester, Mass., and at Peekskill, N. Y., and at the present time controls the larger proportion of the emery produced in this country. The company, however, is doing but little with the development of the corundum deposits in the United States, although it has done extensive work on the deposits of this mineral near Conbemere, Ontario, Canada.

The Montana Corundum Co. continued development work on its deposits near Saleville, Mont., and the Bozeman Corundum Co. was engaged in exploring the Blankenship property near Bozeman. A detailed account of the year's progress in Montana will be found later in this section.

In North Carolina, the North Carolina Corundum Co. has continued operations

of emery. A decrease in price to 5c. per lb., would prevent the operation of some of the mines that are now being developed.

The production of corundum and emery in the United States in 1902 was less than that in 1901, which is not due to a lessened demand for these minerals, but to the close competition with foreign emery, and to an uncertainty regarding the price and market for corundum. There is still too much tendency on the part of the producer to believe that the market for corundum and emery is practically unlimited, for when it is considered that the total amount of these abrasives used in the United States in 1901 was only about 16,000 tons, it can readily be understood how easily the market can be flooded. This would mean a drop in prices, which would be disastrous to many companies.

Montana.—(By Leverett S. Ropes.)—The discovery of corundum in Montana reported in THE MINERAL INDUSTRY, Vol. X., was followed by encouraging developments during 1902, which promise a permanent supply of high-grade product from this source. The mine of the Montana Corundum Co. has been placed on a producing basis, and the Blankenship and Anceny properties have been prospected with favorable results. The mines and prospects are situated in the central belt of gneiss shown on the Three Forks Folio of the U. S. Geological Survey, one property lying to the east and the others to the west of the Ells Creek fault. The geological formation is syenite overlain by beds of hornblendic rock and heavy quartz reefs which may represent metamorphosed sediments of Pre-Cambrian age. Near the boundary of the syenite, the corundum is found in what appear to be veins, although they may represent thin intrusions, as the walls show the effects of great heat. The walls are usually well defined and bear evidence of having been subjected to considerable movement. On the property of the Montana Co. the vein strikes S. 39° W. with a dip of from 42° to 50° N., while at the Anceny prospect the strike is a little south of east and the dip 45° south. The hanging wall is the same for both veins, thus indicating that they occur in the wings of a synclinal fold. The Montana Corundum Co. began developing its property in the early part of 1901, and by the close of the following year had opened up a large supply of ore. A mill was erected during 1902, but the work was so delayed that active operations were not attempted until the beginning of 1903, when the plant was started on a run of eight hours per day, giving an output of 20 tons of graded concentrates. The mill equipment consists of a 10×16-in. Blake crusher delivering to a belt conveyor that carries the crushed product to a 100-ton storage bin in the main mill. From here the ore passes through a set of 27×14-in. New Standard rolls, and is then passed over three vibratory screens of 8-, 5-, and 3-mm. mesh, the oversizes returning to the rolls. The undersizes are treated in 3 two-compartment jigs from which the product is elevated to a storage bin over a second set of rolls, after passing which it goes to a Pratt-Wethey separator with 2·5-mm. screens. The oversize is returned to the rolls, while the undersize passes directly to a muller, which is continuous in its action. From the muller both overflow and spigot products are sent to a hydraulic classifier making three products, two of which pass to rubber-top Bartlett tables, and the third to the tailings pond. The tables bring the concentrates to the required degree of purity, and the

the grader room for reconcentrating any size that may be found impure. Power will be furnished by three 150-H.P. boilers and two engines aggregating 525 H.P.

EMERY.—*Greece.*—The emery deposits on the Island of Naxos are mined by the natives under the control of the Grecian Government, which purchases the crude product at 2·5 fr. ($0·48) per long cwt. (112 lb.). The ore is shipped to the adjacent island of Syra at the expense of the Government, and is there sold at 106·5 fr. ($20·55) per metric ton. The alumina content of the Naxos emery is sometimes as high as 60%. The exports of Naxos emery during 1901 were 5,691 metric tons, valued at $121,215, as compared with 6,328 metric tons, valued at $134,160 in 1900. Of the annual output of Naxos emery, the United States consumes about 25%, the balance being shipped to Europe. The Naxos emery mines have never been leased. Two years ago an American company endeavored to secure a monopoly of the industry by offering the Grecian Government an agreement to purchase 7,000 tons of emery per year for 10 years at 106·5 fr. ($20·55) per ton. The negotiations, however, failed.

Turkey.—The deposits of emery in Turkey are scattered along the coast of the Mediterranean and adjacent islands. The principal mines are at Baltizik, Azizieh, Cosbounar, and Kuluk, near Smyrna. The Turkish Government owns a few of the mines, but many are owned and operated by local companies and individuals. The mined ore is hand-picked before shipment, and is never crushed or washed. The corundum found in the Turkish emery varies from 40 to 57% Al_2O_3, with the exception of Kuluk ore, which is said to contain 37% Al_2O_3. The Kuluk emery is brought down from the neighboring mountains by camels and is shipped at a price f. o. b. Kuluk of $10@$12 per ton. The total annual exports of Smyrna emery range from 17,000 to 20,000 tons, of which about 10,000 tons are shipped to America, the balance going to Europe. During 1901 the value of the quantity of emery exported amounted to $265,140. The price of Smyrna emery varies with the quality from $14@$20 per ton f. o. b. Smyrna. It is reported that emery cannot be produced f. o. b. Smyrna for less than $12·50 per ton.

EMERY WHEEL MANUFACTURE.—The Norton Emery Wheel Co., of Worcester, Mass. (the largest abrasive wheel concern in the world) has erected an extensive plant at Niagara Falls, N. Y., and since the latter part of 1902 this company has been manufacturing artificial corundum from bauxite, which is claimed to possess superior abrasive qualities, exceeding carborundum both in toughness and cutting efficiency. The new abrasive is known as "alurundum," and is made in a manner similar to the process used for the manufacture of carborundum, the impurities being reduced and volatilized by the heat of the electric furnace. The resultant alumina is obtained in a molten condition and assays 98·5% Al_2O_3. It is reported that this abrasive can be produced at a cost less than that of either natural corundum or carborundum. The method of treatment is as follows: The bauxite is charged into the upper end of a coal-fired calcining furnace, and the calcined product when cool is charged into electric furnaces using 500 H.P. When the material becomes molten two carbon electrodes are dipped into the bath and fresh supplies of bauxite are added from time to time as the contents become melted. When the operation is completed the electrodes are removed and the

molten material allowed to cool in the furnaces for from three to four hours, after which the solidified mass is removed and placed on the floor for further cooling. The mass is then coarsely broken and shipped to the main works at Worcester. The product is flinty in appearance and contains at times beautiful small crystals of pure alumina resembling sapphire and ruby. In fact these are artificial gems but are too small in size to possess any economic value.

The plant of the Hampden Corundum Wheel Co. at Springfield, Mass., which was destroyed by fire in 1901, has been thoroughly rebuilt with special reference to the replacement of hand labor by mechanical devices to transport the material in the works during treatment. Down-draft kilns are used having the top in the form of a flattened dome which is utilized as a drying floor during the firing. The wheels to be burned are packed in fire brick boxes and are surrounded with coarse emery or corundum in place of quartz formerly used for this purpose; this method not only saves the expense of the quartz supply, but, in addition, the heat otherwise lost is utilized to burn the crude material. The general arrangement of the new plant is as follows: The crude ore is crushed in the crusher room and distributed to the grading room, where it is washed, dried and elevated to the molding room, where the wheels are fashioned by hand or hydraulic press. The molding room is directly below the grading room, and the wheels when molded are conveyed to the drying room directly above the kilns and dried. They are then placed in the kilns and burned. The fired wheels are dressed and hubbed in the turning room; and when finished are carried to the stock room and stored ready for shipment.

III. Cryolite.

The imports of cryolite into the United States continue to be derived from the mines in Greenland, and the statistics of quantity and value since 1891 are given in the subjoined table. These shipments were made by the Pennsylvania Salt Manufacturing Co., of Natrona, Pa., which possesses the exclusive privilege to import this mineral into North and South America. The remainder of the output of the Ivigtut mines is shipped to Copenhagen.

IMPORTS OF CRYOLITE INTO THE UNITED STATES FROM 1891 TO 1902, INCLUSIVE. (*a*)

Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.
1891..	8,296	$76,350	1894..	10,684	$142,494	1897..	10,115	$135,114	1900..	5,437	$72,763
1892..	7,241	96,992	1895..	9,425	125,868	1898..	6,201	88,501	1901..	5,383	70,886
1893..	9,574	126,688	1896..	3,009	40,056	1899..	5,879	78,676	1902..	6,188	85,640

(*a*) The values are those reported by the Custom House and represent the estimated cost at the mines. There being no United States Consul at shipping point in Greenland, a *pro forma* invoice is prepared for Custom House purposes, wherein the value represents only a small part of the actual cost at buyers' factory.

The value of cryolite in the United States is stated to be $80 per ton of 2,240 lb., and results from the following items: Cost at the mine in Greenland, royalty to Danish Government, ocean freight, inland or domestic freight, cost of separating the pure cryolite, grinding and packing in barrels, and other minor expenses.

According to a report furnished by the Danish Government the total output

of cryolite from the mines at Ivigtut, Greenland, was 8,960 metric tons in 1900, and 7,997 metric tons in 1901. An article on sodium fluoride will be found in the section on "Fluorspar," later in this volume.

IV. Aluminum.

The production of aluminum in the United States continues to be supplied by the sole producer, the Pittsburg Reduction Co., of Niagara Falls, N. Y., and during 1902 the quantity produced was 7,300,000 lb. as compared with 7,150,000 lb. in 1901. The demand for the light metal in the electrical trade, particularly for purposes of electric current conduction, and in the metal trade as a substitute for zinc and brass, continues to be large. The details of the production and prices of aluminum together with its utilization, properties, etc., will be found in the special review of progress in the aluminum industry during 1902 which is given later in this section.

The subjoined tables give the production, imports and exports of aluminum in the United States and other of the principal countries in the world from 1898 to 1902 inclusive.

PRODUCTION, IMPORTS, AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year	Production.			Imports. (b)	Exports.	Consumption. (a)
	Pounds.	Value.	Per Lb.	Value.	Value.	Value.
1898	5,200,000	$1,690,000	$0·325	$4,879	$238,997	$1,454,882
1899	6,500,000	2,112,500	0·325	14,840	291,515	1,835,825
1900	7,150,000	2,288,000	0·32	47,688	281,821	2,053,867
1901	7,150,000	2,238,000	0·31	104,168	183,579	2,158,589
1902	7,300,000	2,284,590	0·313	215,082	116,052	2,383,570

(a) The consumption each year includes a certain amount of manufactures imported; while the production represents the crude aluminum only. (b) The bulk of the imports is in crude condition.

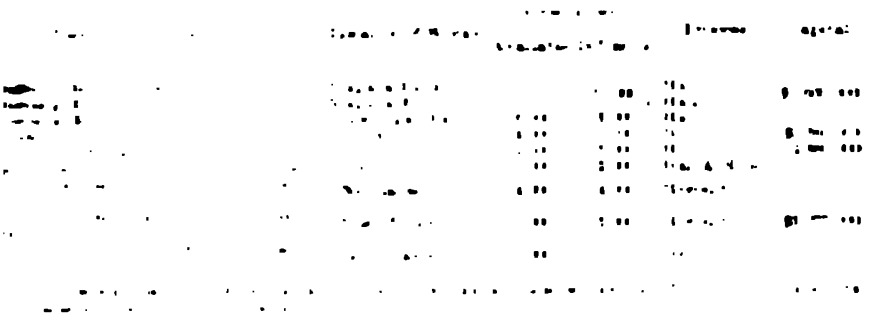
The statistics of aluminum production in Europe are not authoritative, several of the important companies being unwilling to make their figures public. The *Metallgesellschaft*, of Frankfort-on-Main, gives the following statistics for Europe in its last annual report, to which we have added our own figures for the United States, the official figures for France, and those of C. Le Neve Foster for England previous to 1900.

ALUMINUM: WORLD'S PRODUCTION AND COMMERCE. (IN KILOGRAMS.)

Year.	Germany.	Switzerland.		England.	France.			United States. (a)		Total Production.
	Imports.	Production.	Exports.	Production.	Production.	Imports.	Exports.	Production.	Imports.	
1897..	942,400	800,000	706,000	630,000	470,000	6,360	224,000	1,814,866	854	3,394,446
1898..	1,104,000	800,000	677,300	310,000	565,000	5,972	187,955	2,358,705	27	4,033,705
1899..	922,000	1,300,000	604,200	550,000	703,000	8,468	256,242	2,948,381	94,223	6,570,089
1900..	943,400	2,500,000	571,200	568,960	1,026,000	8,300	323,700	3,243,219	116,353	7,338,179
1901..	1,089,600	2,500,000	504,100	560,000	1,200,000	11,400	306,600	3,311,213	255,696	7,871,211

(a) The United States has been an exporter of aluminum for several years, but these exportations were not enumerated by the Bureau of Statistics of the Treasury Department until 1898, in which year they amounted to $239,997. (b) C. Le Neve Foster, British Mineral Statistics for 1897.

United States Duty.—The duty on aluminum imported into the United States is 8c. per lb. on ingot metal and 13c. per lb. on sheet and manufactured metal.



Prof. Richards the 1902 production in the three works situated at Niagara Falls, N. Y., and Shawinigan Falls, Canada, will reach 4,500 tons.*

Using these figures as basis for calculation, I estimate that the total world's production of aluminum in the nine factories manufacturing the metal in 1901 and 1902, has been as follows:—

	1901.	1902.
European works (6)	4,000 metric tons.	3,800 metric tons.
American works (3)	3,240 metric tons.	4,200 metric tons.
Total	7,240 metric tons.	8,000 metric tons.

In spite of the fact that the production of aluminum in recent years has been rather in excess of the demand, two new works are being planned, and one of these is in course of erection.

At Massena, N. Y., the Pittsburg Reduction Co. has bought land, and has commenced to erect a works for the utilization of the water power already developed at this spot, by the St. Lawrence Power Co. This company in the years 1898-1901 has erected large hydraulic engineering works between the Grass River and the St. Lawrence River, developing 50,000 H.P. at Massena, at a capital expenditure of $10,500,000. Unfortunately the St. Lawrence Power Co. has become involved in financial troubles, and the plant and works have now passed into the possession of a syndicate representing some of the original bondholders. The reorganization of the affairs of the company, which is now proceeding, may possibly retard the manufacturing operations of the Pittsburg Reduction Co., but it is stated that the new factory will be in operation by April, 1903. The plant now being installed is of 1,200-H.P. capacity, and consists of four 300-H.P. sets, generating current at 500 volts. It is intended gradually to increase the plant as the demand for aluminum grows, and an ultimate utilization of 12,000 H.P. is in prospect.[1]

The second new aluminum works is being promoted by a Franco-Spanish syndicate, and it is intended to erect a works at Zudavic in Spain. Water power is to be used, but no other details of the new venture have yet been published. In view of the present unsatisfactory state of the industry in Europe, it is probable that the development of this new center for production of aluminum will be long delayed.

As regards prices in 1902 there is little variation to report, as compared with 1901. The November, 1902, prices for the products of the Pittsburg Reduction Co., were as follows: No. 1, *metal*, guaranteed over 99% Al, 33@37c. per pound; No. 2, *metal*, guaranteed over 90% Al, 31@34c. per pound; nickel-aluminum alloy (less than 10% Ni), 33@39c. per pound; powdered aluminum, 90c.@$1 per pound; aluminum castings, 45c. per pound.

All the above prices were subject to discounts ranging between 10% and 15%.

Rod and wire varied in price between 38 and 52c. per lb., according to the gauge, and a rebate of from 3 to 4c. per lb. was allowed off the list

* The production of aluminum by the Pittsburg Reduction Co. at Niagara Falls during 1902 amounted to approximately 3,300 metric tons.—[EDITOR.]

[1] *The Electrical Review*, New York, Sept. 20, 1902.

Rheinfelden and Lend Gastein. Capital, $3,077,000. Gross profits for 1901, $391,027. Dividend for 1901, 13%, an advance of 0·5% upon that paid in 1900. It is interesting to note that this company is carrying out extended trials with Heroult's process for the electrical reduction of iron ores, and that it also utilizes some portion of its available power for calcium carbide production.

The *Société Electro-Metallurgique Française*, with works at Froges and Le Praz. Capital, $2,880,000. No details are available relative to profits or dividends. This company produces ferrochromium and ferrosilicon in addition to aluminum,—and it is also experimenting at Le Praz with the Heroult process for the direct production of iron and steel in the electric furnace.

The British Aluminium Co., with works at Foyers, Scotland. Capital liability, $3,079,000 (authorized capital, $3,360,000). This company has never been able to pay a dividend on its ordinary share capital, but for some years it has kept up payments on the debentures and preferred shares. In the year 1901, the profits did not admit of payment of the preferred interest, and in 1902, the profits were insufficient to meet the interest payments due on the debentures. Payment falling due on Nov. 1, 1902, was defaulted, and the control of the company is now practically in the hands of the bondholders—representing $1,440,000.

The managing director of the company, Mr. Ristori, resigned in May, 1902, and the chairman, Mr. Roger Wallace, K.C., has also resigned, but retains his seat on the Board. A loan of $48,000 has been raised to provide the necessary working capital, and it is hoped that the changes made in the business and technical management of the company under the new chairman, Mr. J. D. Bonner, will lead in time to a more favorable financial result. The sales of aluminum by the British Aluminium Co. in 1902, are reported to have increased 40%, as one result of the improvements effected by the new management. In my opinion, over-capitalization and bad management on the technical side of the business, have contributed largely to this company's difficulties; and time and patience will be required, before it finds itself free from the more permanent effects of these embarrassments. In the directors' statement to the shareholders, the following contributary causes are also mentioned: Overvaluation of stocks; lock-up of capital in large Scotch water-power schemes; legal expenses in attempting to prolong life of patents; and bad speculative investments in bauxite properties in Ireland.

The Compagnie des Produits Chimiques d'Alais, with works at St. Michel, in France. No details relative to capitalization and profits, are available for publication.

The position as regards patents has not undergone alteration in 1902. The Heroult Patents for the United Kingdom, have now expired, but under the conditions obtaining at present in the industry, it is unlikely that any attempt will be made by British manufacturers to enter into competition with the Foyers Works.

With regard to details of the reduction process as actually carried out in the works, Haber and Geipert have published details of laboratory investigations

carrying capacity to No. 6 copper,—erected one year,—no trouble experienced, but gauge too small.

3. Standard Electric Co., San Francisco, Cal.—200 miles of cable,—time not mentioned. Satisfactory.

4. City of Healdsburg, Cal.—8·75 miles No. 4 wire, and the same length of No. 10 wire,—erected 3 years. No trouble experienced.

5. Kansas City and Leavensworth Railway, Wolcott, Kan.—feed wires in use 2 years. Satisfactory.

6. Hartford Electric Light Co., Hartford, Conn.—11 miles of cable,—erected 3 years. Entirely satisfactory.*

These reports speak well for aluminum, but there is a note at the end of the article referred to, which seems to indicate that the new metal in its normal state, is not quite so resistant to weather influences as the reports would lead one to believe. This note is to the effect that: "Weatherproof aluminum wire is being largely introduced in the distributing systems of many of the cities in California and Washington." *"Weatherproof wire,"* can only mean wire coated with some protective composition. If bare aluminum is so entirely satisfactory when used for overhead transmission lines, why is *weatherproof* wire now being introduced?

As regards the use of aluminum for conducting purposes in Europe, there is little progress to report. Mr. J. Gavey, the English Post Office Electrician, has informed me that no further trials have been made with aluminum wire for telegraphic or telephonic purposes, and that at present there is no intention to institute fresh experiments. No reports have yet appeared relating to the condition of the three Italian transmission lines constructed of aluminum, and there is a similar lack of information respecting the lighting installation at Northallerton in England.

Mr. F. C. Perkins, an American writer, in an article which appeared in translated form,[5] gave a *résumé* of the position, as regards the use of aluminum and copper, for electrical purposes. This article contained little that has not been published in previous volumes of THE MINERAL INDUSTRY. No reference was made to the experiments upon durability carried out by Gavey and others, and Mr. Perkins cannot be considered to have given a fair and impartial decision upon the relative merits of the two metals, when used for overhead work.

My own series of exposure tests, with aluminum and other wires at Waterloo, England, commenced in 1899, have been continued during 1902, and some details of the latest results obtained, will be found under the sub-heading *"Properties."*

Alloys.—Guillet, during 1902, has read a paper before the French Académie des Sciences, giving an account of the properties of alloys of aluminum and tungsten obtained by the Goldschmidt process. Three alloys were obtained—represented by the formulæ: AlW_2, Al_3W, and Al_4W. The last named alloy had

* In addition to the above-mentioned equipments 21 miles of aluminum wire were purchased by the Lewiston & Auburn Electric Co., for the transmission of electric power; 20 miles of aluminum wire by the Boston & Maine Railroad for use at Concord, N. H., and 100,000 lb. of aluminum wire by the Boston Electric Light Co.

[5] *Zeitschrift fuer Elektrochemie*, Aug. 14, 1902.

for those aëronauts who have been experimenting with flying machines, and there is little to record beyond a series of accidents, not, it may be remarked, in any way due to the aluminum used in the construction of these navigable balloons.

The Zeppelin airship, which two years ago was attracting much attention, has been broken up, owing to the financial troubles of its designer, and the aluminum rod and wire used in its construction (reported to amount to 5 tons in weight) have been sold. The Severo airship, in which aluminum was used for strengthening the bamboo at many points in the structure, also came to grief early in 1902, and the inventor and his assistant lost their lives at Paris, in the explosion which brought about the collapse of the balloon in mid-air. M. Santos-Dumont, hitherto the most lucky and successful of the aëronauts who have experimented with navigable balloons, has also made little advance during 1902. His latest airship is constructed of cypress and bamboo rods, strengthened by aluminum thimbles at the splices; but nothing noteworthy has been done with it during the past year.

It will be noticed from the above that the tendency in airship construction is to use bamboo and similar light woods for the frames in place of the metal aluminum, and to employ the latter metal only for strengthening the frame at the joints.

As regards the use of aluminum for cycle construction, there is also little progress to report during 1902, but in motor car work the new metal and its alloys are growing in favor and usefulness. The Winton Co., of Cleveland, Ohio, is using aluminum, and J. M. Quinby & Co., of Newark, N. J., is reported to have constructed a 16-H.P. automobile of the Panhard type, with the body of the vehicle constructed entirely of the light metal.[10] At the Paris (1902) show of cycles and automobiles, Charpentier & Co., of Valdois, had an exhibit of aluminum which attracted considerable attention. Sheets and ornamental panels of strengthened aluminum (renforcée) were the chief novelties of this exhibit. The use of aluminum for wheels of automobiles has also been tried by one French builder, while the automobile firm, Charron, Girardot & Voigt, is using aluminum and the alloy, partinum, to a large extent in construction work.

Printing.—The use of aluminum as a substitute for stone and zinc in lithographic work is rapidly extending, and both in London and New York companies have been formed to manufacture the special rotary printing presses, designed for this new departure in lithography. The Aluminum Press Co. is the name of the American company, and the Aluminium Rotary Press, Limited, is the title of the English company, which has been floated with a capital of $960,000 to purchase the English patents and to equip a factory for the manufacture of the presses at Otley, in Yorkshire. Thirty of the new rotary aluminum presses are stated to have been sold in Enrope, and the list of well-known lithographic printers who have one or more of the new presses in use, or who have ordered one, is growing in number every day. W. H. Smith & Co., of London; De la Rue & Sons, of Bolton, and E. S. & A. Robinson, of Bristol, are a few of the English firms who have started during 1902 to use the new metal for

[10] *Electricity*, New York, July 30, 1902.

work. The first named firm has informed me, that it finds the ... an excellent substitute for stone in lithographic work. The manipulation is no different from that required when stone is used, that compensation in the handling of the new material is necessary in order ... best results. The best practical information relating to this new ... of aluminum is to be found in a series of articles published in the ... A further development in this use of aluminum has ... by Mr. ..., who has devised a method of printing on textile goods ...

... and Metallurgical Use. Although this remains one of the most ... for the aluminum produced in Europe and America, little new ... relating to it has been published during 1901. In France the sales ... for foundry work are reported to reach ... tons per annum, and ... chairman of the British Aluminium Co., when the metal ... used for this purpose it is rarely given up. In the United Kingdom ... of the metal to the steel works has been small and disappointing; ... it was stated that use is believed to absorb a considerable portion ... of the Pittsburg Reduction Co.

... depending upon the ... aluminum process for the production ... by means of powdered aluminum, have made progress during ... the Thermite Steel Industry continues to manufacture ... and alloys of iron and the rare metals. In a recent independent ... on tramway construction, welded rails were specially mentioned ... forms of bonded joints, and the Goldschmidt method ... shown to be put forward as the most convenient and useful ...

... Aluminium World, January and February, 1902.
... Aluminium World, February, 1902.

Chemical Apparatus.—According to O. Guttman, aluminum is proving of value in the manufacture of explosives. In the preparation of nitro-cellulose it is requisite to use vessels which are unattacked by a mixture of sulphuric and nitric acids. An aluminum vessel has successfully resisted the action of these acids for some months, although either acid alone was found to have action upon it.[14]

Explosives.—"Ammonal," a new explosive patented by Fuhrer, of Vienna, contains 25% Al in the state of powder, and ammonium nitrate. The Electro-smelting (Zinnoxyd) Co. of London, which would appear to be a subsidiary of the company operating at Essen, also manufactures an explosive of which powdered aluminum is an ingredient, but I am unable to say whether this compound is similar in all other respects to ammonal. This company reported a dividend of 12% in 1902.

Fuse Wires.—A novel use of aluminum is found on the Niagara-Buffalo transmission line, where the new metal is used not only for the main conductors but also for the fuse wires. This transmission is at 11,000 volts.

Gramophones.—The American Gramophone Co. is trying an alloy composed of 95% Zn and 5% Al for the metallic portions of its machines. A somewhat similar use is that of aluminum for the diaphragms of telephones.

Golf Clubs.—W. Mills, of Sunderland, England, who makes a special feature of aluminum castings and has attained much success in this direction, has cast a set of golf-clubs heads in the light metal. H. H. Hilton, the noted golf player, has seen these novel clubs and is reported to have recommended them.

Lamps.—According to a writer in the paper named below,[15] aluminum is used by several makers of miners' lamps in Germany. The new metal is also reported to be in use for making the reflectors of acetylene lamps, but as there is not a great sale for these, the consumption of aluminum for this purpose cannot be large.

Machinery and Other Castings.—At the foundry of W. Mills, Sunderland, England, 75 men are reported to be constantly at work on aluminum castings.

Whetstones and Sharpening Wheels.—According to A. Bernard, of Hamburg, Germany, a valuable property of aluminum has been discovered in its ability to sharpen cutlery. Aluminum has a fine-grained structure and develops during the whetting process an exceedingly fine metal-setting substance which is greasy to the touch and adheres strongly to steel. An examination of a knife blade whetted on aluminum under the microscope at 1,000 diameters magnification, shows the edge of the steel to be perfectly uniform and unbroken, which is not the case when steel is sharpened on stone.

Properties of Aluminum.

Reference has already been made to the laboratory experiments of Haber and Geipert upon the electrolytic separation of aluminum in baths of fused cryolite. These investigators examined the chemical and mechanical properties of the

[14] *Aluminum World*, July, 1902. From *Journal of the Society of Chemical Industry*.
[15] *Engineering*, London, Aug. 22, 1902.

of removing the impurities from bauxite, described in THE MINERAL INDUSTRY, Vol. X., and based upon incipient fusion with sufficient carbon to reduce the iron and silicon present as oxides, is about to be operated at Niagara Falls.[19] From these statements it is evident that the Pittsburg company is alive to the importance of reducing the cost of the raw materials of the manufacture.

Interesting historical notes relating to the development of the aluminum industry in America have appeared in the journals named below during the past year.[20]

V. ALUM AND ALUMINUM SULPHATE.

ALUM, ARTIFICIAL.—The reported production of aluminum sulphate in the United States during 1902 amounted to 87,075 short tons, valued at $1,938,671, as compared with 74,721 short tons, valued at $1,793,304 in 1901, while the production of crystallized alum was 8,539 short tons, valued at $229,500, as compared with 7,755 short tons, valued at $233,250 in 1901. The apparent large decrease in the production of crystallized alum during 1901 and 1902, as compared with preceding years, has resulted from the method of calculation necessary prior to 1901, the year in which statistics of production were first collected directly from the producers.

The statistics of the production of alum and aluminum sulphate given in the following table previous to 1901 are computed from the consumption of bauxite and cryolite in the United States, and the production of metallic aluminum, it being assumed that what was not used for the manufacture of aluminum, was used for making the sulphates. The yield of American bauxite, and the quantity imported are well known, consequently the method of determining the production in so far as it is expressed in terms of crystallized alum is fairly accurate. The division into crystallized alum and aluminum sulphate is estimated, and is therefore approximate. However, since it is apt to be misleading to report the entire production as crystallized alum, of which really only a comparatively small quantity is made, the statistics for 1898 to 1900 have been reported in the modified form. Any apparent discrepancy is thus accounted for. The statistics for 1901 and 1902 have been collected directly from the producers.

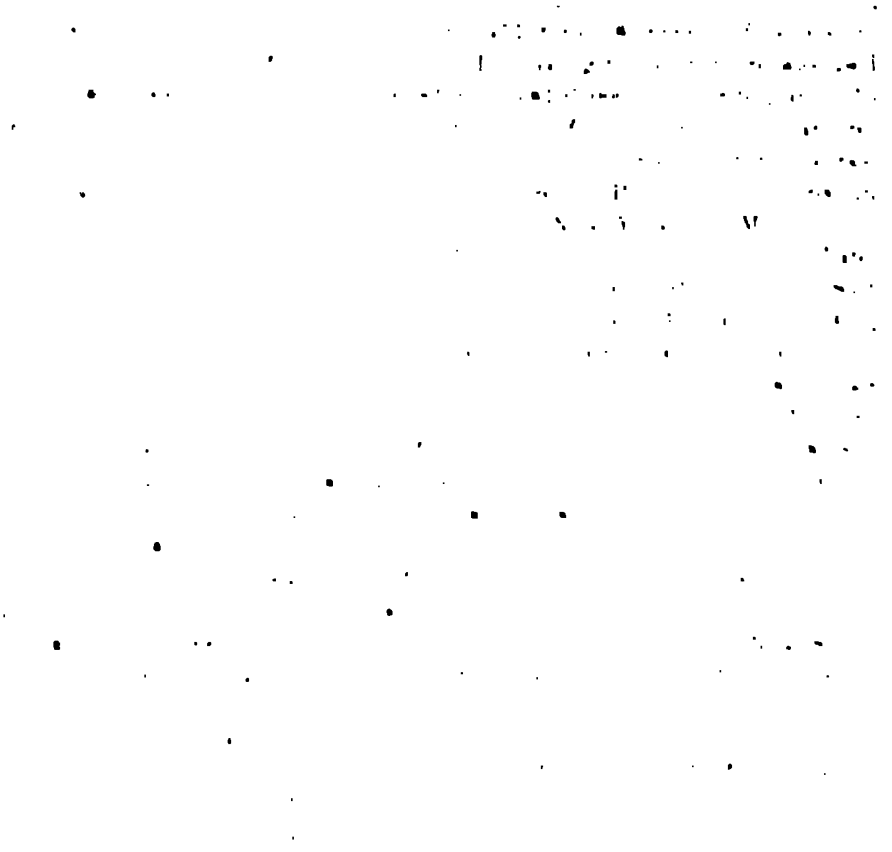
UNITED STATES PRODUCTION AND IMPORTS OF ALUM FROM 1898 TO 1902.

Year.	Production.								Imports. (a)		
	Alum.			Aluminum Sulphate.			Total Reckoned as Alum. Sh. Tons.	Total Value.	Short Tons.	Value.	Per Ton.
	Short Tons.	Value.	Per Ton.	Short Tons.	Value.	Per Ton.					
1898..	18,791	$563,730	$30·00	56,663	$1,416,675	$25·00	97,302	$1,980,405	(b) 898	$16,187	$18·13
1899..	27,276	845,556	31·00	81,805	2,106,479	25·75	127,430	2,952,035	(b) 858	14,953	17·49
1900..	20,531	615,930	30·00	61,678	1,480,272	24·00	105,743	2,096,202	(b) 1,169	22,288	19·07
1901.c	7,775	233,250	30·00	74,721	1,793,304	24·00	.....	2,026,554	(b) 1,091	20,781	19·05
1902.c	8,539	229,500	26·85	87,075	1,938,671	22·25	.....	2,168,171	(b) 929	16,808	18·09

(a) Includes alumina, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground. (b) There was also imported in 1898, 1,205 short tons ($76,884) of aluminum hydrate, or refined bauxite, in 1899, 1,926 short tons ($119,202), in 1900, 2,207 short tons ($148,332), in 1901, 1,966 short tons ($146,462), and in 1902, 336 short tons ($21,235). (c) Through the courtesy of the United States Geological Survey.

[19] *Aluminum World*, October, 1902.

[20] *Electrochemical Industry*, No. 1, 1902; *Electrical Review*, New York, Nov. 15, 1902.



AMMONIA AND AMMONIUM SULPHATE.

By Henry Fisher.

The production of ammonia (reported as its equivalent sulphate salt) and ammonium sulphate by by-product coke oven plants in the United States during 1902 is estimated at 65,000 metric tons, and for 1901 at 60,000 metric tons, which shows the active development of this industry due chiefly to the increase in the number of by-product coke ovens now in operation. The manufacture of ammonia and ammonium sulphate in the United States and in Europe during recent years is discussed in complete detail in the paper by Dr. F. Schniewind, on "The Manufacture of Coke, with Especial Reference to the Markets for By-products," which is given in The Mineral Industry, Vol. X., pp. 135 to 166.

The imports of ammonium sulphate into the United States, from 1898 to 1902, were as follows:—

Year.	Pounds.	Metric Tons.	Value.	Value per Metric Ton.
1898	11,057,762	5,016	$210,073	$41·88
1899	17,121,988	7,766	406,573	52·35
1900	24,034,188	10,897	591,987	54·33
1901	31,711,085	14,384	728,085	50·62
1902	35,535,588	16,119	858,036	53·23

The world's production of ammonium sulphate during 1902 exceeded 548,500 metric tons, as compared with 523,000 metric tons in 1901. Of this quantity, Germany contributed 135,000 tons and France 65,000 tons. The product is used mainly in the manufacture of fertilizers.

The following table shows the world's production of ammonium sulphate and exports of sodium nitrate from Chile, the latter being practically identical with

WORLD'S PRODUCTION OF AMMONIUM SULPHATE AND SODIUM NITRATE. (a)
(IN METRIC TONS.)

	1898.	1899.	1900.	1901.	1902.
Ammonium sulphate:					
Great Britain	196,500	208,000	210,000	220,000	225,000
Germany	100,000	110,000	120,000	130,000	135,000
United States	49,000	52,000	58,000	60,000	65,000
France	35,000	36,000	37,000	38,000	40,000
Belgium, Holland, Sweden, Norway and Denmark	30,000	32,000	33,000	35,000	38,000
Austria, Russia, Spain, and other European countries	30,000	30,000	25,000	40,000	45,000
Total production	440,500	468,000	493,000	523,000	548,000
Sodium nitrate:					
Exports from Chile	1,265,000	1,370,000	1,430,000	1,270,000	1,325,000
Nitrogen equivalent in metric tons of world's sulphate production	87,220	92,600	97,610	103,550	112,000
Nitrogen equivalent, in metric tons, of Chile's nitrate exports	197,970	214,400	223,800	198,760	208,000
Total	285,190	307,060	321,410	302,310	321,000
Percentage of sulphate	30·6%	30·2%	30·3%	34·3%	35·1%
Price of 2,000 lb. nitrogen at Liverpool, in—					
Sulphate (10,101 lb.)	$208·80	$248·20	$244·15	$232·80	$260·00
Nitrate (12,779 lb.)	191·05	232·10	225·50	249·40	256·00

(a) *Zeitschrift fuer angewandte Chemie*, April 23, 1901; *L'Engrais*, Jan. 24, 1902 and 1903; Annual Report of the German Sulphate Syndicate for 1901.

STATISTICS OF AMMONIUM SULPHATE PRODUCTION AND CONSUMPTION OF THE UNITED KINGDOM FROM 1896 TO 1902, INCLUSIVE. (*a*) (LONG TONS.)

	1896.	1897.	1898.	1899.	1900.	1901.	1902.
From gas plants	127,000	153,000	130,000	133,768	142,419	142,708	146,000
From blast furnace	16,500	18,000	17,700	17,963	16,959	16,358	17,000
From shale works	38,000	37,000	37,300	38,780	37,267	40,011	38,000
From coke ovens, producers, etc.	9,000	10,000	11,500	15,209	17,081	18,146	20,500
Total production	190,500	498,000	196,500	205,720	213,726	(*b*) 217,213	(*c*) 221,500
Consumption of United Kingdom	65,000	45,000	59,600	67,600	64,700	69,800	58,746

(*a*) *Zeitschrift fuer angewandte Chemie*, April 23, 1901, and *Bradbury & Hirsch's Review* for 1902, excepting for 1899, 1900 and 1901, which are from the *Annual Report of the Chief Inspector of Alkali Works*, etc. (*b*) Of this amount, England furnished 139,716 tons; Scotland, 75,062 tons; and Ireland, 2,835 tons. (*c*) Of this amount, it is estimated that England contributed 145,000 tons; Scotland, 74,000 tons; and Ireland, 2,500 tons.

In the removal of hydrogen sulphide from the gases evolved in the manufacture of ammonium sulphate by the Hemingway iron sulphite process, the following reaction takes place:—

$$FeSO_3+3H_2S=FeS+3S+3H_2O.$$

The exports of the United Kingdom during 1902 were 162,754 long tons, of which 10,084 tons were shipped to the United States. The consumption of the United Kingdom in 1902 is assumed to be 58,746 long tons, the difference between the production and exports.

ANTIMONY.

By Joseph Struthers

[illegible] of smelting antimony ores and refining the metallic product is [illegible] and very few metallurgists know the complete details [illegible] Successful smelting, therefore, can only be accomplished [illegible] This fact, together with large production of the [illegible] the recent removal of the import duty on crude antimony [illegible] ocean freight rates from foreign countries, hinders, if not [illegible] the profitable production of antimony metal from domestic ores in [illegible]

[illegible] of any metallic antimony produced from domestic [illegible] during 1909, due to the tariff decision rendered April [illegible] United States General Appraisers at New York, which re[illegible] ad valorem duty on crude antimony (the partly refined [illegible] placing it on the free list. The production of metallic anti[illegible] during 1909 amounted to but 50 tons, an extremely [illegible] when compared with the total annual consumption of this metal [illegible]

[illegible] of the production and trade in antimony is in [illegible] plant [illegible] and the [illegible] the [illegible] of San Francisco, Cal. [illegible] of the [illegible] [illegible] has [illegible] [illegible] [illegible]

The aggregate quantity of antimony metal, or its equivalent in antimony alloys or salts, produced from the above-mentioned sources in the United States during 1902 amounted to 12,486,000 lb., as compared with 8,971,884 lb. in 1901.

A large part of the domestic demand for antimony metal, particularly for manufacture into anti-friction and similar alloys, is supplied in the form of antimonial or hard lead, containing generally from 18 to 27% Sb.

The statistics of imports, production and consumption of antimony in the United States, from 1898 to 1902, inclusive, are given in the subjoined table.

IMPORTS, EXPORTS, PRODUCTION AND CONSUMPTION OF ANTIMONY IN THE UNITED STATES.

Year.	Imports.					Exports.			
	Metal or Regulus.		Ore.		Total Value.	Metal or Regulus.		Ore.	
	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.	Pounds.	Value.
1898	2,025,133	$143,909	3,725,222	$50,256	$194,165	25,275	$1,729	34,312	$784
1899	3,160,697	240,988	3,992,133	47,841	288,829	16,815	1,275	*Nil.*	.....
1900	3,632,843	285,749	6,085,734	78,581	364,330	23,590	2,352	*Nil.*	.....
1901	3,674,923	255,846	1,731,956	24,256	278,597	*Nil.*	.....	49,655	1,536
1902	5,425,923	336,311	3,337,600	67,570	377,375	37,184	2,710	208,581	4,608

Year.	Production.				Consumption.
	In Hard Lead. (a)	From Domestic Ores.	From Imported Ores. (b)	From Imported Regulus or Metal.	Total Supply.
	Short Tons.	Short Tons.	Short Tons.	Short Tons.	Short Tons.
1898	2,118	250	870	1,052	4,290
1899	1,586	234	1,041	1,495	4,356
1900	2,476	151	1,599	1,827	6,053
1901	2,235	50	364	1,837	4,486
1902	2,904	*Nil.*	626	2,713	6,243

(a) Estimated at 25% of the total quantity of hard lead produced, except for 1902 which was estimated at 27%. (b) Estimated 40% extraction from net import of ore.

The large increase in the quantity of antimony ores and regulus imported and exported during 1902 has been due to a peculiar condition of the freight rates from China, which strangely enough were about 10s. per ton from China to New York, and 30s. from China to England. The freight rate from New York to England being about 10s. per ton, shipments were made first to New York, where the metal was trans-shipped to England, thus saving practically one-third of the cost of direct transportation.

The supply of antimony for domestic consumption as metal or as lead alloy is derived from the following sources: (1) hard lead produced as a by-product from the smelting or refining of lead ores and bullion of both domestic and foreign origin, (2) imported ores or crude antimony, (3) imported metal or regulus, and (4) domestic ores. The only antimony ore of commercial importance in the United States is stibnite, antimony trisulphide (Sb_2S_3), and while many deposits of this mineral occur in the Western States, the production of metal therefrom has never reached an important position, the largest quantity produced annually being but 295 short tons in 1895 in an estimated total production of 4,000 tons of metal from all sources. Since 1895 the production of antimony from domestic ores has declined until there was none so produced in 1902.

Mexico.—The antimony production from Catorce in the State of San Luis Potosi, in recent years, has been large enough to dominate the price of the metal in Mexico. The ore occurs as an earthy oxide in limestone near the surface, and as shipped, contains more than 45% Sb. A metallurgical plant for local treatment of lower grade ores containing from 30 to 40% Sb has been erected at Wadley. Heretofore the ore has been shipped to Newcastle, England.

Portugal.—The principal antimony mines are on the Commune of Gondomar, in the Porto district: the ore occurs also in the Braganza district. During 1902 the exports of antimony ore amounted to 54 metric tons, valued at $1,739 as compared with 126 tons, valued at $2,650 in 1901.

Turkey.—The supply of antimony ore is derived from the mines at Allkhar, near Rozdau, and near Aidin. The export shipments of ore from Salonica during 1900 amounted to 267 metric tons, valued at $13,965.

The New York Antimony Market in 1902.—Although the consumption of antimony in 1902 was larger than in 1901, the market was rather depressed throughout the year, prices ruling considerably below the figures of the previous twelve months. Sales of wholesale lots were difficult to effect. The Italian, French, Japanese and Hungarian brands made heavy inroads in the trade previously controlled by the standard English (Cookson's and Hallett's) brands, partly on account of the fancy prices asked, especially for Cookson's metal, and partly on account of the improving quality of the cheaper grades.

The comparatively easy tone of the antimonial lead market also tended to restrict the demand for antimony.

The year opened with Cookson's selling at 10c.; Hallett's, 8·25c.; Hungarian, Italian, Japanese and U. S. Star at 7·75c. From month to month the prices declined, holders being anxious to sell and willing to make concessions for fair-sized orders. The market closed rather dull and depressed at the lowest quotations of the year, 8·5@8·75c. for Cookson's, 7@7·125c. for Hallett's, 6@8·75c for Italian, French, Japanese, Hungarian and U. S. Star brands.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (IN CENTS PER POUND.)

Year.	Brand.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1898....	Cookson's.....	8·00	8·00	8·25	8·37	9·20	9·65	9·75	9·75	9·75	9·70	9·25	9·25	9·08
	Hallett's.....	7·37	7·56	7·81	7·96	8·64	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·51
	U. S. Star.....	7·50	7·59	7·81	7·92	8·64	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·52
	Japanese	7·44	7·58	7·81	7·90	8·59	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·51
1899....	Cookson's	9·31	10·25	10·37	10·10	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·37
	Hallett's.....	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·65	9·72	9·75	9·75	9·67
	U. S. Star.....	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·56	9·50	9·50	9·50	9·65
	Chapman's.....	.....	9·62	9·75	9·80	10·00	10·00	10·00	.....	.....	.....	.....	.....	.....
	Hungarian	.....	.....	9·75	9·80	10·00	10·00	.....	9·75	9·56	9·50	9·50	9·50	.....
1900....	Cookson's	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·10	10·00	10·00	10·00	10·31
	Hallett's.....	9·75	9·75	9·75	9·75	9·69	9·62	9·53	9·50	9·30	9·25	9·25	9·25	9·63
	U. S. Star.....	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·30	9·25	9·25	9·25	9·46
	Cookson's	10·00	10·00	10·00	10·31	10·25	10·25	10·25	10·25	10·12	10·09	10·00	10·00	10·13
1901....	Hallett's.....	9·12	9·22	8·90	8·94	8·75	8·75	8·75	8·63	8·50	8·47	8·37	8·31	8·71
	U. S. Star.....	9·25	9·06	8·80	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·69
	Hungarian.....	.....	8·75	8·75	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·61
	Italian.....	.....	8·75	8·75	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·61
	Japanese	.....	.....	.....	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·61
1902....	Cookson's	10·00	10·00	9·87	9·87	9·87	9·87	9·75	9·75	9·69	9·44	9·25	9·20	9·71
	Hallett's.....	8·17	8·04	8·06	8·06	8·17	8·25	8·25	8·15	7·92	7·72	7·44	7·25	7·76
	U. S. Star.....	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67
	Hungarian	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67
	Italian.....	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67
	Japanese	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67

TECHNOLOGY

HCl gas, precipitating the $SbCl_3$ with H_2S, and weighing the Sb_2S_3 form
The chloride solution for arsenic is prepared by dissolving 300 g. $CuCl_2$ c
stals in 1 liter of HCl (sp. gr. 1·2), and adding a solution of $ZnCl_2$ with b
ing point of 180°C. The $ZnCl_2$ solution may be prepared by adding 1 lb. st
zinc to 1,250 c.c. HCl (sp. gr. 1·2), boiling and evaporating to bring the b
ing point to 180°C. The I in 1 c.c. of the iodine solution corresponds to 0·005
As. It is prepared by dissolving 40 g. KI in water, adding 17 g. I and dilut
to 1 liter when the I is dissolved. In order to standardize it, 300 mg. As_2O_3
are dissolved in KOH or NaOH, the solution is diluted to 1,200 c.c., and slight
acidified with HCl, 2 g. $NaHCO_3$ are added, and the titration carried to a p
manent blue. A check should be made by dissolving 300 mg. As_2O_3 as befor
precipitating with H_2S, distilling the sulphide (as shown below), titrating th
distillate, and deducting from assays the number of c.c. required in excess o
the standard. A check distillation of the $CuCl_2$ and 200 mg. C. P. Cu is nece
sary, and the distillate titrated; the number of c.c. required have to be deducted.
The determination is as follows: Weigh 1 g. ore, place in a casserole, add 10 c.c.
HNO_3 (sp. gr. 1·42) and warm. When the evolution of red fumes ceases,
add 10 c.c. H_2SO_4 (sp. gr. 1·84) heat only to copious fumes of SO_3, as arsenic
is liable to be volatilized. Allow the solution to cool, add 40 c.c. water and
10 c.c. HCl, and boil to dissolve all soluble matter. If antimony is to be deter-
mined, add $H_2C_4H_4O_6$. Filter if necessary, otherwise wash into a beaker, reduce
to a colorless solution with a mixture of one part NH_4HSO_4 and two parts con-
centrated NH_4OH, adding it drop by drop, and stirring until the precipitate
re-dissolves. In case any of the hydrates formed do not dissolve, add HCl.
In the presence of much Au, Se, or Te, these metals will be precipitated by an
excess of H_2SO_3, and will darken the nearly colorless solution. Darkening of
the solution shows that enough reducing agent has been added. Boil to drive
off excess of SO_2, introduce H_2S in a rapid stream until the precipitates begins
to collect, filter, wash free from iron salts, and test filtrate with H_2S. Wash
precipitate with dilute HCl (1 part water to 1 part HCl, sp. gr. 1·2) into a dis-
tillation flask, connected with a Liebig condenser set vertically. Add 50 c.c.
$CuCl_2$, close flask with a rubber stopper containing a thermometer reaching to
within 0·25 in. of the bottom, and let end of condenser dip 0·5 in. into 40 c.c.
water in a beaker. Heat to 115°C. and collect distillate. If much arsenic is
present, remove rubber stopper, add 15 c.c. to 25 c.c. strong HCl and distil again.
Make the distillate alkaline with NH_4OH, acidify with HCl, cool, add 2 g.
$NaHCO_3$, then starch solution and titrate.

If antimony is to be determined, replace the stopper holding the thermometer
by another, with a glass tube reaching nearly to the bottom of flask and connect
with a HCl gas generator. Heat the distilling flask until the contents are nearly
dry and collect the distillate in cold water as before. (Overheating causes
$CuCl_2$ to pass over.) When the distillation is finished, add a little $H_2C_4H_4O_6$
to distillate, nearly neutralize with NH_4OH and pass in H_2S. If colored Sb_2S_3
is precipitated, repeat distillation until no Sb is precipitated. Filter the Sb_2S_3
through a Gooch crucible, heat in an air bath at 225°C. for one hour and weigh;
the weight obtained multiplied by 0·714 gives the antimony content. The

[illegible] take about 15 minutes. The results are as [illegible] obtained by the Pearce method for arsenic [illegible] however the results for antimony are liable to [illegible] Bromate to replace $CuCl_2$ with $FeCl_3$ proved unsatis-

[illegible] *Hard Lead.* The determination of the [illegible] containing 20% Sb has been made by F. W. [illegible] with the following results:

[illegible]					

[illegible] copper, arsenic, etc., which occur in hard lead do [illegible] When making the determination, care [illegible] otherwise the outer layer may coal [illegible] which on cooling contracts and [illegible]

[illegible] Zeitung, 1911, Nos. 19, 1912, p. 117.

ARSENIC.

By Joseph Struthers.

The production of arsenious oxide (white arsenic) in the United States during 1902 was 1,353 short tons, as compared with 300 short tons in 1901. The entire product was made by the Puget Sound Reduction Co., at Everett, Wash., which began the manufacture of this important product in 1901. The largely increased output in 1902 is a very favorable sign of the success of the new industry. Aside from the arsenic ores which occur in the United States, there are several chemical and metallurgical by-products rich in arsenic—as speiss from the lead smelters, and precipitated arsenic sulphide produced in the purification of sulphuric acid—which should be utilized in some way to replace the large quantities of arsenic compounds that are imported annually from Europe and Canada. The occurrence of arsenic ores and the metallurgical practice of England and Germany are described in Vols. II. and IV. of The Mineral Industry.

Imports.—The quantity and value of the imports into the United States of white arsenic (arsenious oxide), metallic arsenic and arsenic sulphides (orpiment and realgar) during the past five years are as follows: 1898—8,686,681 lb. ($370,347); 1899—9,040,871 lb. ($386,791); 1900—5,765,559 lb. ($265,500); 1901—6,989,668 lb. ($316,525); and 1902—6,110,898 lb. ($280,055).

New York Market.—The average monthly price of white arsenic at New York during 1902 was as follows: January, 3·34c. per lb.; February, 3·58c.; March, 3·5c.; April, 3·37c.; May, 3·25c.; June, 3·16c.; July, 3·04c.; August to December (inclusive), 2·94c., giving an average of 3·16c. per lb. for the entire year, as compared with 3·92c. during 1901. The average monthly price of red arsenic (from Germany) at New York during 1902 was: January, 7·03c. per lb.; February, 7c.; March, 6·87c.; April, 6·63c.; May, 6·72c.; June to December (inclusive), 6·88c., giving an average of 6·86c. per lb. during the entire year, as compared with 7·04c. during 1901. Pure Paris green in bulk sold at 11@12·5c. per lb. during 1902, as compared with 12@12·5c. during 1901.

Prior to 1899 the world's supply of arsenic and arsenical compounds was derived chiefly from the mines at Cornwall and Devon, England, and at Freiburg, Germany, but the closing of the Devon Great Consols mine, near Tavistock, in 1901, called for an increased or new supply from other localities. In 1900 Canada contributed a small quota, which has since been largely increased, and in 1901 the United States became a producer on a small scale, and more than *quadrupled its* output for 1902.

The product resulting from this operation is a crude arsenic containing about As_2O_3, 85%, and S, 2 to 4%, the balance being silica in a finely divided state.

The crude arsenic is sublimed in two specially designed single-hearth reverberatory furnaces, the charge in each case being 1,600 lb. Each furnace has a capacity of three charges per 24 hours. The arsenic, upon being volatilized, is driven through a long hot flue and thence into an uptake or hot chamber; during the passage through these any impurities that may have been carried over with the highly heated gases are deposited when the cooling commences, being assisted by mechanical means, throughout a series of cooling chambers. When the gases have been cooled to 80° F. they are forcibly ejected into a large condenser and made to expand and contract alternately until perfectly cooled and free from arsenic. They then escape into the open air.

The resultant arsenious oxide is pure; analyses showing from 99·6 to 100% As_2O_3. The impurity is silica, doubtless derived from the mortar and brick of which the chambers are built. The refined arsenic is withdrawn from the chambers every two weeks; it is dropped into hutches, which are tightly closed for the double purpose of keeping the oxide warm as long as possible and preventing the escape of the poisonous dust into the building. Finally, the arsenic is ground to a 200-mesh size and a conveyor takes it to the packer, where it is automatically packed in substantial wooden kegs containing an average of 500 lb. each and is ready for the market.

A new occurrence of native arsenic has been reported at the Corporation (Forsyth) quarry, near Montreal, Ontario. The mineral occurs in concentric layers forming masses often of several pounds in weight. An analysis gives As, 98·14%; Sb, 1·65%; S, 0·16%; insoluble, 0·15%. No silver, bismuth, or other metal was found.

France.—The production of arsenic ore in France during 1901 amounted to 7,500 metric tons, valued at $38,000. The entire output was derived from two mispickel properties in Villanière et du Salsigne (Aude).

Germany.—The production of arsenic ore in Germany during 1901 was 4,060 metric tons, valued at $78,000, as compared with 4,380 tons in 1900, valued at $79,000.

India.—Arsenic sulphide ores occur at Munsiari, in Kumaon, Chitral, in the Punjab, and in various localities in Upper Burma and Unan. The annual imports of orpiment and realgar during the past three years have averaged 638,400 lb. The foreign imports in 1900-1901 amounted to 309,792 lb., valued at 56,390 rupees, and were derived mainly from Germany, the United Kingdom, Hongkong, and the Straits Settlements. It is impossible to determine what proportion of the imports of pigments (if any) represent arsenic, but the consumption of white arsenic, orpiment and realgar in the industries of India must be extensive.

Italy.—During 1901 there were produced 6 metric tons of arsenic ore, valued at $96.

Spain.—A white arsenic works has been established at Badalona, near Barcelona, by Messrs. Gironés and Henrich, to treat the arsenical pyrites of Caralps

Production of Germany. It is reported that these works produce 10 tons per [illegible] white arsenic assaying from 99·8 to 99·9% arsenious oxide.

Arsenic in England. The arsenic industry in England during 1902 has been [illegible] as the price obtainable for white arsenic fell to so low a [illegible] its manufacture from arsenic ores became unprofitable in many cases. [illegible] at the Devon Great Consols Co., Ltd., was discontinued [illegible] pending negotiations affecting the renewal of the lease of the [illegible]

The production of arsenious oxide in 1902 was 2,464 metric tons, as [illegible] 3,616 tons, valued at £107,230 in 1901, and 4,116 metric tons, [illegible] £131,100 in 1900. According to the thirty-eighth report of the Alkali [illegible] an improvement in arsenic manufacture in Great Britain has been [illegible] by the erection of a condensing tower containing 2 tons of iron rods [illegible] apart, whereby 70% of the arsenious acid passing [illegible] is removed. This appears to be an adaptation of the Rossing [illegible] arsenious oxide condensation.

Separation of Arsenic and Copper in Iron Ores. F. Bischoff passes H_2S [illegible] the solution of iron, copper and arsenic, which is maintained [illegible] at 70°C. The solution is allowed to stand for 10 hours and [illegible] through a filter, the precipitate is washed with H_2S water, placed [illegible] a 3–5% NaClO solution added and Cl gas passed until the solution [illegible] a green colour. It is allowed to stand for a few hours, filtered, washed, [illegible] and Cl expelled by boiling, then transferred to a platinum dish, [illegible] and ignited. The precipitated copper hydrate is filtered, washed, [illegible] ignited in the usual manner. To the filtrate containing the [illegible] added [illegible] NH_4Cl and NH_4OH to alkaline reaction, the solu-

[illegible] precipitated with magnesia mixture

[illegible] Arsenic and Antimony in Sulphides. See under the sec-
[illegible] earlier in this volume.

[illegible] for Arsenic Process for Arsenic. See page [illegible] of this

[illegible] Fumes from Furnace Gases. George C. Stone has [illegible] for the separation and recovery of arsenic fumes from furnace [illegible] flue dust and which consists in conducting the gases to [illegible] chamber, flue [illegible] the deposited material in [illegible] subsequent recovery of the arsenic or its compounds [illegible] with reagents to heat whereby the metal is volatilized [illegible] condensed.

[illegible]
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ASBESTOS.

By Henry Fisher.

There was an increase of nearly 50% in the production of asbestos in the United States during 1902 over the previous year, the output being 1,010 short tons, valued at $12,400, as compared with 747 short tons, valued at $13,498 in 1901. The value of the product at the mine decreased from $18·07 per ton in 1901 to $12·27 in 1902, a decrease of nearly 50%. The Sall Mountain Asbestos Co., at Sall Mountain, White County, Ga., continues to be the largest producer of asbestos in this country.

PRODUCTION AND IMPORTS OF ASBESTOS IN THE UNITED STATES.

Year.	Production.				Imports.		
	Short Tons.	Metric Tons.	Value.	Value per Metric Ton.	Manufactured.	Unmanufactured.	Total.
1898.....	885	803	$13,425	$16·72	$12,899	$287,636	$300,535
1899.....	912	827	13,860	16·76	8,949	303,119	312,068
1900.....	1,100	998	16,500	16·54	24,155	331,796	355,951
1901.....	747	678	13,498	19·91	24,741	667,087	691,828
1902.....	1,010	916	12,400	13·54	33,313	729,421	762,734

PRODUCTION OF ASBESTOS IN THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Canada.		Cape Colony.(c)		Italy.		Russia.		United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1898.....	21,577	$486,227	161	$10,185	131	$9,000	1,665	$60,600	803	$13,425
1899.....	22,938	483,299	(*b*)	.....	81	7,264	2,663	97,342	827	13,860
1900.....	27,797	748,431	157	12,785	(*b*)	.....	(*d*)	.....	998	16,500
1901.....	36,475	1,259,759	89	7,165	(*b*)	.....	(*d*)	.....	678	13,498
1902.....	36,668	1,203,452	(*d*)	.....	(*d*)	.....	(*d*)	.....	916	12,400

(*a*) From official reports of the respective countries. (*b*) Not stated in the reports. (*c*) Exports. (*d*) Statistics not yet available.

Several discoveries of asbestos have been made in 1902. Five asbestos claims have been located in the chrome district in Tehama County, Cal., and another deposit has been located in Pinto Creek, near Globe, Ariz. The fiber from the latter deposit, which is reported to be large, is of the long variety. The Pine Mountain Mica & Asbestos Mining Co. has been organized at Indianapolis, Ind., to develop asbestos and mica mines in Georgia and North Carolina. The Mad River Asbestos & Talc Co. has been incorporated at Kittery, Me., to mine asbestos, talc and other minerals.

Uralite is the name given to a new fireproof material composed of asbestos fiber, chalk, sodium bicarbonate and silicate, invented by a Russian artillery

ASPHALTUM.

By Joseph Struthers.

The aggregate production in the United States during 1902 of all mineral bituminous products, embracing as well that portion of the residuum from the refining of petroleum which is sold and used as asphaltum, was 83,651 short tons, valued at $615,659, as compared with 63,134 short tons, valued at $555,335 in 1902.

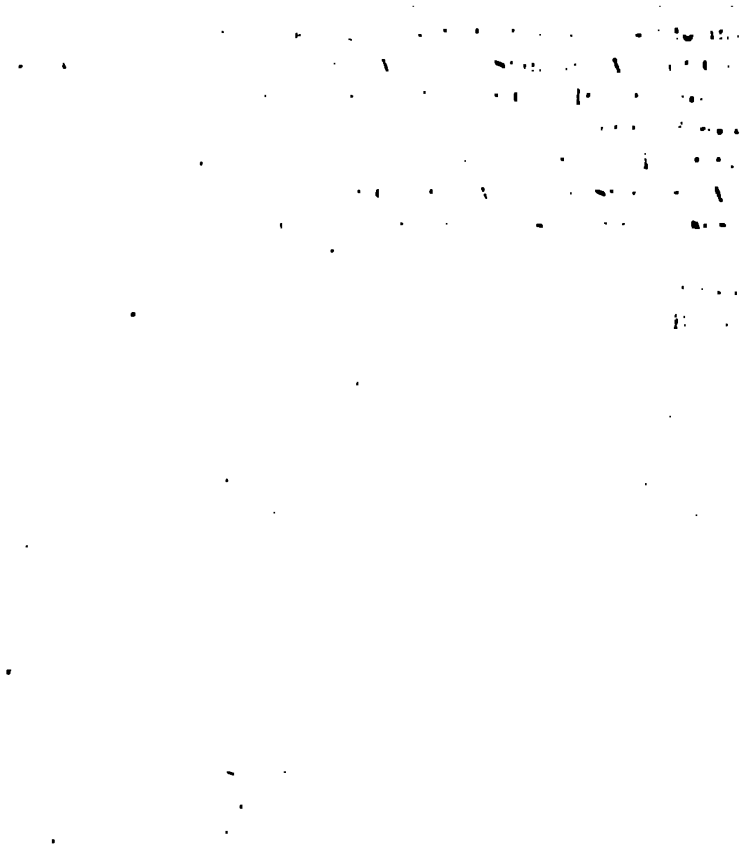
PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES.
(IN TONS OF 2,000 LB.)

States.	1900.			1901.			1902.		
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Bituminous sandstone:									
California	a25,355	a$101,420	$4·30	24,306	$77,661	$3·15	33,489	$79,809	$2·38
Kentucky	8,922	37,472	4·20	8,942	56,610	6·33	22,498	68,704	3·05
Indian Territory	.....	.....	.....	1,000	4,330	4·33	(e) 1,050	4,580	4·36
Arkansas	.....	.....	.....	.....	.....	.....	800	4,000	5·00
Total	34,277	$138,892	$4·05	34,248	$138,601	$4·05	57,837	$157,093	$2·72
Asphaltic limestone:									
Utah	2,550	12,750	5·00	*Nil.*	.....	.....	*Nil.*	.....	.....
Indian Territory	1,360	4,080	3·00	2,970	15,375	5·20	1,120	4,080	3·56
Texas	.....	.....	.....	4,000	18,000	4·50	*Nil.*	.....	.....
Arkansas	.....	.....	.....	.....	.....	.....	700	3,500	5·00
California	.....	.....	.....	.....	.....	.....	29	202	9·06
Total	3,910	$16,830	$4·30	6,970	$33,375	$4·79	1,859	$7,782	$4·19
Asphaltum:									
California	d11,140	218,520	19·62	b 19,988	316,559	15·83	f(g)29,282	382,301	13·06
Indian Territory	.....	.....	.....	98	1,000	10·20	376	3,219	8·56
Texas	.....	.....	.....	330	19,800	60·00	(g) 945	3,992	16·29
Gilsonite:									
Utah	3,279	98,370	30·00	c 1,500	46,000	30·67	4,052	61,162	15·10

(a) Statistics of the California State Mineralogist. (b) Includes 1,000 tons of liquid asphaltum valued at $49,850. (c) Estimated. (d) Includes production in Indian Territory. (e) Includes production of Oklahoma Territory. (f) Includes 1,600 tons of liquid asphaltum, valued at $20,137. (g) Includes by-product asphaltum from refining crude oil.

The production of bituminous sandstone in the United States during 1902 was 57,837 short tons ($157,093) as compared with 34,248 short tons ($138,601) in 1901. Practically the entire output was obtained from California and Kentucky. The quantity of bituminous limestone produced in 1902 from the deposits of Indian Territory and Arkansas amounted to 1,859 short tons ($7,782), as compared with 6,970 short tons ($33,375) in 1901; probably a part of the by-product asphaltum from the refining of crude oil was included in the Texan statistics for 1901. The production of hard asphaltum in California, Indian Territory and Texas during 1902 (including by-product from oil refining and 1,605 tons of

Kentucky.—(By William E. Burk.)—The deposits of bituminous sandstone or asphalt rock in Kentucky occur chiefly in the counties of Logan, Warren, Edmonson, Butler, Grayson and Breckinridge, occupying a strip in the central part of the State that extends from Breckinridge County on the north to Logan County on the south. A few deposits are found also in the western parts of Hardin, Hart and Larue counties. The asphalt-bearing territory apparently follows the line of the Coal Measures, and is about 20 miles wide by 50 miles in length. The main basin of highly mineralized rock is located well to the south, the richest deposits being found in Logan and Edmonson counties. A bituminous deposit also exists in Carter County, in the northeastern part of the State; the material is impregnated sandstone, but it appears to lie in a basin altogether different from that which extends into West Virginia, and portions of which are found scattered over other eastern counties of Kentucky. The deposits occur in fine-grained sandstone of the Sub-Carboniferous formation. The strata usually approximate their normal horizontal position, and from geological evidence, it is probable that the bituminous or asphalt material represents the residual matter from pre-existing petroleum beds. The soft, porous sandstone, which once was saturated with petroleum, has been eroded away, and the channel streams of ancient rivers have cut deeply into the rock. This has resulted in valleys and hills of sandstone from which the lighter products and oil have distilled and drained away, leaving residual petroleum products constituting the asphalt or bitumen. The fact that petroleum-bearing rock formerly existed where the present asphalt rock occurs should not be taken to mean that quantities of petroleum must occur at lower depths, for the underlying strata may represent altogether different formative conditions. The bituminous deposits, though quite generously distributed in Grayson and Edmonson counties, are in no sense uniform as to richness and magnitude. The horizontal ledges vary in thickness from 2 to 20 ft. In many cases the deposits are quite lean; the material locally called "black-rock" contains only a small percentage of bituminous material, and has no commercial value. The known deposits of commercially valuable material are few. The richer deposits are usually enclosed by strata of "black-rock" from 1 to 2 ft. in thickness, while the intervening portion of asphalt ledge varies from 3 to 15 ft. in thickness, and contains from 5 to 15% total bituminous matter. When containing under 4%, the material passes under the class of "black-rock." Deposits containing as high as 20% are of small extent, and usually due to local concentration conditions. Of the total bituminous content about 20% is of the nature known as asphaltene, and 80% of petrolene. After the removal of the bituminous matter the sandstone crumbles to a very fine sand. One characteristic sample upon examination showed 8·5% of sand that passed through a 150-mesh, and 82·5% that passed through a 75-mesh sieve. In the present state of development only those deposits lying conveniently near railroad or river have received attention, and of such only those have been worked which offer the least difficulty in the way of uncovering. Although rich material is sometimes exposed in bluffs, no tunnelling or drifting has been attempted. This district is entered by the Green River and its prominent tributaries. Considerable asphalt rock has been moved by barge to Ohio River points. The Green River Asphalt Co.,



plant at Bowling Green, to which point the spalls are shipped by water. In this plant corrugated rolls are used and hot air is injected into the stream of ore as it comes from the crusher to expel moisture. This plant has a capacity of 200 tons per day.

The property of the Breckinridge Asphalt Co. is situated in Breckinridge County near the town of Garfield. At the plant of this company the broken asphalt rock passes through beaters revolving about a horizontal shaft. The first beater revolves at a velocity of 600 revolutions per minute, delivering the rock to a 2-in. screen. A second beater revolving at a velocity of 1,200 revolutions per minute takes the material and delivers it to a 0·25-in. screen. Material over 0·0625-in. ($\frac{1}{16}$) is returned to beaters. The capacity of the plant approximates 100 tons per day.

The property of the Federal Asphalt Co., near Big Clifty, in Grayson County, has been slowly developed, owing to a fire which destroyed the mill on the first day of operation. The erection of another plant of large capacity is contemplated.

THE WORLD'S PRODUCTION OF ASPHALTUM AND ASPHALTIC ROCK. (*a*) (IN METRIC TONS.)

Year.	Austria.	France.		Germany	Hungary.	Italy.		Russia.	Spain.	
	Asph. Rock.	Asphaltum	Asph. Limestone. (*b*)	Asphaltum.	Asphaltum.	Asphaltum. (*h*)	Asph. Rock.	Asphalt.	Asphaltum	Asph. Rock.
1897	300	17,932	30,946	61,645	3,057	18,644	55,339	22,222	1,878	1,[illegible]
1898	643	18,832	36,000	67,649	3,125	17,813	93,750	12,018	2,354	2,[illegible]
1899	2,635	22,100	39,000	74,770	3,060	41,732	81,987	23,061	2,646	2,[illegible]
1900	887	25,228	34,093	89,685	2,900	33,127	101,738	(*d*)	2,331	4,[illegible]
1901	541	20,391	29,815	90,193	2,878	31,814	104,111	(*d*)	4,189	3,[illegible]

Year.	Trinidad. (*e*)	United States.		Venezu'la (Bermudez). (*e*)
		Asphaltum. (*f*)	Asphaltic Rock. (*g*)	
1897....	133,310	24,854	45,233	11,528
1898....	108,792	23,906	57,728	*Nil.*
1899....	144,340	13,662	50,061	12,014
1900....	161,299	(*i*)8,326	41,029	17,981
1901....	167,253	(*i*)19,882	37,393	22,115

(*a*) From the official reports of the respective countries, except where noted to the contrary. The production of gilsonite in the United States and Manjak in Barbados is not included. (*b*) France produces a large amount of bituminous shales, used for distilling oil, which is not included in these statistics. (*d*) Not yet reported. (*e*) Exports (crude equivalent) reported by The New Trinidad Lake Asphalt Co. (*f*) Statistics reported by the California State Mineralogist, practically the entire American product being derived from California. (*g*) Statistics based on direct reports from the producers, including asphaltic limestone and sandstone. (*h*) Including mastic and bitumen. (*i*) Statistics of the United States Geological Survey.

NOTE.—There is a consi erable production of asphaltic stone in Switzerland of which no account is taken in the above table, the Swiss Government not publishing any mineral statistics.

THE ASPHALTUM INDUSTRY IN FOREIGN COUNTRIES.

Cuba.[1]—(By H. C. Brown.)—The output of asphalt in 1901 amounted to 4,554 tons, valued at $96,380, of which all but 500 tons were exported. Of the total shipments New York received 3,300 tons, while 754 tons went to Europe, the bulk of which went to Germany and a small portion to England. The selling price ranged from $12 to $50 per ton, according to quality. There were nine concerns engaged in mining asphalt, and the individual output varied from 24 tons to 1,400 tons.

Province of Pinar del Rio.—A Spanish company has denounced asphalt

[1] Through the courtesy of the United States Geological Survey.

west of the Sierra de Ore, and is engaged in developing several The Magistrana and Rolas Concepcion mines, which have been worked [illegible] the past, were reopened, and a railroad was constructed to [illegible] for the product. The company operating these [illegible] a contract with the Trinidad Asphalt Manufacturing [illegible] to furnish 500 tons of asphalt per month, and has arranged [illegible] to operate at their convenience to New York. An analysis [illegible] gives total bitumen, 51·00%; insoluble material [illegible], moisture, 2·00%; rock material (principally lime-[illegible].

[illegible] Havana. The West Indies Co., of New York, which operates the [illegible] near Bejucal, has shipped asphalt to New York and Wash[illegible] as paving material, it being known in trade as the "Royal Palm" [illegible] of the asphalt is given in THE MINERAL INDUSTRY, Vol. X[illegible] is located on the United Railways of Havana, about 19 miles [illegible] Havana was worked during the year, and the product shipped [illegible] European ports. The material is pronounced a pure gilsonite [illegible] and Japan manufacture. The Arizona-Cuban Asphalt & [illegible] incorporated with a capital stock of $[illegible], has denounced [illegible] near Jaruco and is said to own 11 claims in the eastern prov-

[illegible] of Matanzas. The property known as "La Paz," situated 10 miles [illegible] Perico, was operated and the product shipped from Havana to [illegible]. This mine is owned by a Cuban company which is also de-[illegible]

[illegible]

[illegible]

has been operative for several years, and the product is well established in the markets of the United States.

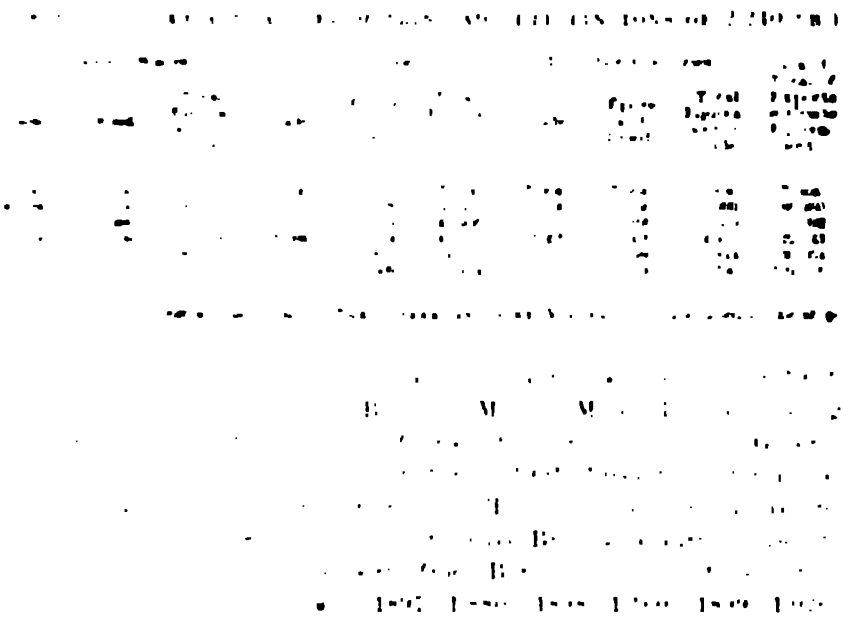
France.—The Val de Travers Asphalte Paving Co., Ltd., reports an income of £46,199 during 1902, and expenses, including depreciation, £12,423. A dividend of £20,000 at the rate of 20% for the year was paid, leaving £2,776 to be brought forward, which, with £10,271 from the previous year, gave a total of £13,047. This company holds the concessions from the Société des Asphaltes du Val de Travers for the exclusive supply to the United Kingdom of rock from the Val de Travers mine, Neuchâtel, Switzerland. It has also acquired the Compagnie Générale des Asphaltes de France for £184,000, to be paid in stock, which company owns property at Pyriment-Seyssel, Seyssel Volant, Chavaroche, and elsewhere in France; bituminous property in Venezuela, mines in Sicily, and property in New York, Alexandria and Charenton, France.

Italy.—In Sicily the asphalt industry is in the hands of a few large companies, who are increasing the capacity of their factories for extracting the bitumen from the asphalt rock and compressing it into blocks, and also for pulverizing the rock for shipment in bags. The three largest concerns are the French Company, which has important mines at Ragusa and Vizzini; the United Limmer and the Sicula Company. A large part of the output is exported from Syracuse and Mazzarellis. In 1901 the exports amounted to 62,770 tons, of which the United States received 11,870 tons, Germany 29,300 tons, Holland 3,750 tons, Great Britain 7,630 tons, and France and Austria-Hungary the balance.

Trinidad and Tobago.—The exports of asphalt from the Island of Trinidad are given in the following table, for which we are indebted to the courtesy of the New Trinidad Lake Asphalt Co., Ltd. Seven-eighths of the asphalt exported is dug from Pitch Lake, which is leased to the company till 1930. The removal of 1,885,000 long tons of asphalt during the past 35 years has apparently made but little impression on the deposit. The New Trinidad Lake Asphalt Co. contributes the greater bulk of the exports, although some 30,000 tons are annually handled by smaller shippers from other properties. The lake contains no liquid asphalt, but in other parts of the island this variety, from which illuminating and lubricating oils can be distilled, is found widely distributed. Glance pitch, also is found on the island, and is used for electric insulations and for black varnishes. Manjak, another variety, has recently been discovered in quantity, about 10 miles north of the pitch lake.

EXPORTS OF LAND ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons	Tons.	Tons.
1898....	18,160	*Nil.*	18,160	700	238	1,087	404	312	872	20,119
1899....	25,618	345	26,130	275	280	695	.....	100	150	26,975
1900....	34,706	(*b*)	34,706	251	(*b*)	251	197	(*b*)	197	35,244
1901....	31,767	11	31,767	1,704	(*b*)	1,704	1,446	(*b*)	1,446	34,917
1902....	25,008	100	25,158	200	.....	200	15	50	90	25,448



OZOKERITE.

The ozokerite deposits at Boryslaw in Galicia, Austria, still continue to supply practically the entire output of the world. The methods of mining and refining the crude material and the uses of the refined product have been fully described in former volumes of THE MINERAL INDUSTRY. Early in 1903, J. Muck published a complete description of the occurrence and refining of ozokerite at Boryslaw, in Galicia, Austria, in a book entitled "Der Erdwachsbergbau in Boryslaw" (Julius Springer, Berlin, 1903).

In the United States during 1902, the Summit Placer Mining Co. and the Utah & Wasatch Co. produced 20 short tons of ozokerite from the deposits at Soldier Summit, Utah. The property, consisting of 16 lode claims, is covered by six 160-acre placer claims. The crude ozokerite is melted and cast into 10-lb. cakes and shipped in sacks, each containing 10 cakes. In 1903, the deposits at Soldier Summit, at Colton (seven miles east of Soldier Summit), and at Midway (four miles west of Soldier Summit) will be operated.

In 1901, the exports of crude ozokerite from Austria amounted to 2,717 metric tons ($554,400) as compared with 5,109 tons ($1,047,085) in 1900, while the exports of the refined product (ceresin) in 1901 were 771 metric tons ($205,200) as compared with 906 metric tons ($234,546) in 1900. Of the quantity exported in 1901 the shipments to Germany amounted to 7·3 metric tons and those to the United States to 24·7 metric tons. The output of ozokerite in Galicia in 1902 was 3,275 metric tons, of which Boryslaw produced 2,565 tons, Dzwiniacz-Starunia 650 tons and Truskawiec 60 tons. There were 8 mines in operation in 1902, as follows: Galizische Kreditbank and Aktiengesellschaft "Boryslaw," in Dzwiniacz; Aktiengesellschaft "Boryslaw," Lautmann; Lucki & Co.; Wolfarth in Starunia; Compes & Co. and Ochrymowicz & Co., in Truskawiec. The average price for the year per metric ton was 1,100 crowns ($220).

PETROLEUM AND MALTHA PRODUCTS USED IN THE PAVING INDUSTRY.

BY A. W. DOW.

THERE is practically nothing known of the chemistry of the petroleum and maltha products, and there are no reliable chemical tests for estimating their value for paving purposes. The greatest demand for such materials is in the bituminous paving industry, where they are largely employed to soften or "flux" hard asphalt for paving cements. They are used also as paving cements without the addition of any of the hard natural asphalt, and in small quantities to grout brick and stone pavements.

Bituminous or asphalt pavements are of two classes, *i.e.*, sheet asphalt, which is laid with a continuous surface; and asphalt block, consisting of paving material pressed into blocks and laid in this form. The same process is used in the manufacture of the paving material in both classes of pavement. The asphalt, if too hard, is softened to the desired consistency by the addition of a suitable flux, this fluxed asphalt being known as asphalt paving cement. The asphalt paving cement, in a molten state is mixed with the heated mineral ingredients, and the asphalt mixture is either hauled to the street and laid as sheet asphalt pavement

cements that are superior to the paraffine residuum cement in ductility and cementing properties, but they are slightly more susceptible to changes in temperature.

The malthas or asphaltic oils from California have been used almost exclusively in the past for fluxing hard asphalts that were only slightly soluble in paraffine residuums; but during the past year they have been supplanted to a large extent by the residuums from Texas oils, due to the cheapness of the latter. The asphaltic oils are very viscous fluids at ordinary temperatures, with a specific gravity ranging from 1 to 0·986 or from 10° to 12° Baumé, and a flashing point somewhat lower than that of the average Texas residuum. They contain no paraffine scales and are homogeneous liquids. Asphalt cements made with these fluxes are more ductile and cementitious but more susceptible to changes in temperature than cement made with the former two oils.

In the early days of the asphalt industry, wax tailings or still-wax was employed in rare cases as a flux for asphalts, but owing to its variable character its use has not expanded. Petroleum refiners state that they are never certain as to the quality of the still-wax to be produced from the run of the still, and no two runs are ever identical even when the same oil is used apparently under the same conditions.

The first solid product from oil for use in the paving industry was produced by refining California maltha by distillation until the residue had the consistency of asphalt paving cement. These asphalt cements were produced about 1890, but they were not extensively used until 1895. When these cements are obtained by ordinary process of distillation, they are characterized by great ductility and cementitiousness, but are very brittle and very susceptible to changes in temperature and in some cases they harden too rapidly by ageing.

In 1892 a patent[1] was obtained for an artificial asphalt, produced by treating petroleum residuum with sulphur at a temperature of about 400°F. The action of sulphur on the oil appears to promote the removal of hydrogen from some of the heavier products of the residuum, forming hydrogen sulphide. This artificial asphalt known to the trade as "Pittsburg flux" is a rubber-like substance even at low temperature; it lacks ductility, and is but little affected by changes in temperature. The inventor, doubtless, intended to use this material in pavements as a substitute for asphalt, but the cementing powers were so low that it has never reached beyond the experiment stage. The material was used to a limited extent, together with residuum, as a flux for asphalt in sheet asphalt pavements, and although the asphalt cements showed less susceptibility to changes in temperature, the improvement was counterbalanced by a decrease in ductility, and for this reason its use for the purpose was abandoned. However, as a flux in the manufacture of asphalt blocks, where the danger from lack of ductility is reduced to a minimum, it has proved superior to the ordinary petroleum residuum.

The same artificial process was applied in 1895 to the asphaltic oils of California; the product obtained possessed greater cementing powers and more ductility than that produced from the paraffine oils. This artificial asphalt was manufactured and used with some success in paving for several years until the *patent was bought* by the Asphalt Trust.

[1] United States Patent No. 468,867, Feb. 16, 1892.

CEMENT

[illegible] natural hydraulic cement and dry cement [illegible] Portland cement [illegible] barrels [illegible] valued [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] CEMENT IN THE UNITED STATES [illegible] BARRELS OF [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SLAG CEMENT.—The output of slag cement in 1902 was 169,435 short tons, valued at $340,000, as compared with [illegible] short tons equivalent to 272,689 barrels made and sold in 1901. The production and value increased materially in sympathy with the highly satisfactory conditions in the Portland cement trade during the latter half of 1902. The decision made by the Board of Engineers, U. S. A., that slag Portland cement cannot be substituted for Portland cement in Government work where the specifications call for the latter, but is to be classed as pozzolana slag cement, has been accepted by most of the slag cement manufacturers and efforts are being made to push the sale of slag cements only for those uses to which they are particularly adapted. A greatly increased production of cement in 1903 unless the state of the iron market is too good to permit attention being paid to the utilization of by-products. The review of the slag cement and slag brick industries of the United States during 1902 is given by Mr. E. C. Eckel, later in this section.

CEMENT PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION IN THE UNITED STATES. (IN BARRELS OF 300 LB.)

Year.	Production.				Imports.		Exports. (b)		Consumption.	
	Natural Hydraulic.	Portland (a)	Total Barrels.	Value.	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
1898	9,161,078	4,999,664	13,150,742	$10,223,922	2,995,092	$2,634,229	70,892	$98,121	15,764,942	$12,749,930
1899	9,996,647	8,007,161	17,753,808	15,490,731	2,810,951	2,556,286	147,089	213,457	20,417,580	18,505,560
1900	9,177,222	11,789,052	20,966,274	15,393,109	3,192,245	3,330,445	196,586	269,186	23,461,933	18,454,368
1901	7,094,423	12,993,914	20,088,337	15,588,638	1,239,456	1,305,662	384,280	752,057	20,993,448	16,142,273
1902	9,993,776	17,092,175	27,185,951	22,023,240	2,659,721	2,561,888	432,189	575,369	29,402,466	24,029,889

(a) Includes slag cement. (b) Includes re-exports of foreign.

IMPORTS OF CEMENT INTO THE UNITED STATES ACCORDING TO SOURCE.

Year.	Belgium.		Canada.		France.		Germany.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1898	133,816	$90,949	955	$8,852	3,459	$22,294	206,982	$1,394,551
1899	124,820	747,448	880	8,868	3,130	22,362	238,799	1,698,732
1900	165,258	1,001,122	908	9,396	6,542	47,798	231,110	1,722,104
1901	60,696	377,517	1,213	12,180	2,354	20,421	112,119	804,710
1902	123,159	724,060	722	8,228	2,984	24,705	251,853	1,692,684

Year.	United Kingdom.		Other Countries.		Total Imports.		Exports. (a)	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons	Value.	Short Tons.	Value.
1898	47,212	$333,405	10,350	$64,247	402,764	$2,634,228	10,633	$98,121
1899	39,927	309,614	14,112	76,372	421,648	2,858,286	22,054	213,457
1900	53,594	416,987	19,989	133,093	477,337	3,330,445	27,998	269,186
1901	7,478	58,570	5,177	32,294	188,978	1,305,662	68,595	752,057
1902	15,817	105,294	4,422	26,887	398,956	2,561,888	74,668	575,369

(a) Estimated from number of barrels reported at 1 bbl. = 400 lb. Includes re-exports of foreign.

THE CEMENT INDUSTRY IN THE UNITED STATES DURING 1902.

BY CHARLES F. MCKENNA.

PORTLAND CEMENT.—No other branch of the mineral industry in the United States has ever furnished more striking figures of rapid yet healthy growth than those encountered in the study of the manufacture of Portland cement. Economists have marveled at the continued steady expansion in the production of pig

engineering practice with concrete there yet remains much to be determined in the study of the ways in which the cement, the water, the aggregates, and the finished concrete shall be treated. Failures and discredit of this material are more often traced to ignorance of these factors than to defective qualities of the cement. Since it is the foreman concreter and the laborer who have most to do with these factors it is obvious that systematic instruction furnished to them would quickly prove its value. It is probable that if manufacturers to-day were not pressed to supply orders, but were rather seeking trade, the effort would take the form of supporting traveling schools of concreting. The influence of the good workmanship thus taught would spread from railroad engineering and municipal engineering to farm engineering, house building, and other fields of activity where the economy of cement, its mode of treatment, and its successful applications have not yet been developed to their full values.

The testing of Portland cement, which has given rise to much friction in the past between manufacturers and consumers, has become better understood and great good has resulted from its application both in the factory and at the site of use. The Committee on Cement Testing of the American Society of Civil Engineers is entitled to much credit for its work in this field, and its report published during the year 1902 is a model of simplicity when it is considered how the subject might have been overburdened with confusing details, which would have discouraged many an earnest experimenter and inspector. The Committee on Cement Testing of the American Section of the International Association of Testing Materials is now co-operating with the committee of the American Society of Civil Engineers, and the investigation of the sufficiency and value of its findings will have the joint support of both societies.

The technology of Portland cement during 1902, while recording no striking invention or improvement, affords many evidences of advance both in the efficiency of apparatus and in better plan and disposition in the works. The rotary kiln is absolutely triumphant, and attention is being concentrated not upon efforts to replace it with any other type, but upon improvements in the details of form and arrangement of burner, selection and care of brick lining, regulation of blast, control of draft, and many minutiæ incident to uninterrupted operation. Undoubtedly the year 1902 can record a general increase of yield per kiln as a result of such attention, and both fuel consumption and labor cost have been reduced to some extent. Heat economies are studied, and a few works are reported to have been successful in utilizing the heat of the flue gases for feed-water heating. The saving of the heat of the clinker also is practiced in some types of clinker coolers, but apparatus of this character must commend itself for simplicity before an attempt to make such a minor saving is warranted. The mechanical engineer also is advancing the art of cement manufacture, and trade rivalry among the promoters of milling machinery is undoubtedly a favorable influence. The battle between the advocates of the Griffin mill and those of the ball and tube mill has continued, and it is believed that improvements have been made on both, so that a continuation of the contest may be expected. A few new works have been designed in which the ball and tube mills are used to grind the raw material and Griffin mills to grind the clinker

which is recommended by some engineers when the materials are a thorough mixing consequently becomes absolutely essential. being made in the steam power plants of mills, in electrical equipdriving and carrying mechanisms, and in every feature open to the mechanical engineer

in the coal trade which supervened in the summer of 1902 produced effect upon the technology not yet fully perceived. The cement manufacture that coal is a very important factor of the total cost of ... of economy being sought which will enable him to ascertain ... use of the coal used and to learn the attendant economics of

... the year of Portland cement during 1903 peculiar features are ... At the opening of the year a feeling of nervousness manifested ... manufacturers which was more pronounced than any before The large stocks accumulating in certain mills appeared to some ... warrant the lack of room for this accumulation at other mills appeared as an additional menace Reports of large increases in production successful companies drove the small manufacturers into a ... competitors relaxed their efforts and ordered but little from ... power ever known in the history of the cement business ... contracts of great magnitude were made. Suddenly upon the ... of winter and its effects, an unexpectedly large demand arose. ... April grew strong in May, and in June hardly an important ... was at least warranted in taking contracts The enormous de... began in June and lasted until the end of the year.

... grade of Portland cement The ... large shipments to the United States, and ... was being ... the factories ... large ... the year ... Portland ... large ... and ... ...

manufacturer still has the opportunity to develop the export trade almost from the very beginning. It would seem that there will be nothing but success for the manufacturer who looks well to the economies, and it seems also as if assurance can be given the user that plentiful supplies will be available.

NATURAL HYDRAULIC CEMENT.—The changing influences of the natural cement products upon the market for Portland cement continued as slight as they have been for several years. This variety of hydraulic material holds its own, but appears to make no progress. At the beginning of 1902 a consolidation of more than 75% of the Rosendale natural cement plants at Rondout, N. Y., was consummated. The production during 1902 of natural cements in this district approximated 2,350,000 bbls. of 300 lb. each. The total production of natural hydraulic cement in the United States during 1902 would be difficult to gauge accurately since the factories are many in number, small in size and much scattered, but it may be stated tentatively at 10,000,000 bbl. Natural cement is produced also at certain mills in Pennsylvania, and mixtures of this product are made with Portland cement. These mixed quantities, however, are not included in the statistics given in the table showing the production of Portland cement in the United States.

Slag Cement and Slag Brick Manufacture during 1902.

By Edwin C. Eckel.

The present paper is supplementary to the detailed discussion of the slag-cement industry contained in Vol. X of The Mineral Industry, and gives a review of progress made during the past year. In addition, however, to supplementary matter relative to the slag-cement industry, the manufacture of slag brick and slag sand is discussed in some detail. These industries were not treated at all in the volume and at present it seems probable that they will soon attain considerable commercial importance in the United States.

General Review. During the past year the slag-cement industry of the United States has been in a very prosperous condition, the production for 1902 largely exceeding that for 1901, while the average value per barrel showed a slight increase. The report of the board of army engineers on slag cements, while it has undoubtedly had a depressing effect on the industry, has doubtless resulted in much good. Several plants manufacturing a puzzolana cement from slag have been in operation for years, frankly announcing both the methods of manufacture and known defects of the material for certain uses, relying on its equally well known value for other uses to accomplish its sale. An extensive correspondence with municipal engineers, which was carried on by me during 1902, showed that those who have experimented with slag-cement for such work as foundations, sewers, etc., regard it with favor, and permit its use in public works. Several new slag-cement plants at various points in Pennsylvania were planned and in part constructed during 1902. Only one of these, however, was completed and in operation before the close of the year. This plant, [illegible] was built by the Universal Portland Cement Co. at Universal, Pa. A description of this plant was made by the writer in the Engineering and Mining Journal, and the plant has since been operated steadily. The cement from it made by the wet process has the following average composition: Silica, 22.22%; alumina, 12.96%; iron oxide, 1.11%; lime, 49.44%; magnesia, 2.22%; sulphuric anhydride, 1.11%. Very good results are reported as to the strength and fineness of the cement. The [illegible] is ground with the clinker in tube mills. The finished cement has the following composition: Silica, 21.22%; alumina, 11.61%; iron oxide, 1.11%; lime, 51.11%; magnesia, 2.22%; sulphuric anhydride, 1.11%.

Experiments were made at the slag-cement plant of the Shenango Furnace Co. [illegible] to determine the [illegible] Department of Agriculture. Powdered coke was employed as a method of regulating the [illegible] of slag cement. [illegible] slag cements [illegible] Slag of the usual composition [illegible] were ground with clinker. If an excess of coke was used, [illegible] 20 parts coke to 80 parts slag. The proportions are 15 to 10 parts coke to 85 parts slag. The

mixture is stirred up with water until of the consistency of a thick paste, and after grinding is formed into bricks and allowed to harden for several days. At the end of this time the bricks are broken into lumps and burned at a dark or bright red heat, according to the rapidity of set desired, and then finally reduced to powder. This process gives a very rapid setting cement. If it is too rapid, the set is retarded to any desired degree by mixing with the cement a greater or less proportion of dry powdered granulated slag and slaked lime. It will be noted that this process is intermediate between the methods used in manufacturing ordinary slag cements, and that adopted in Portland cement manufacture. In fact if the mixing and guiding of the materials were carried on more carefully, and the burning accomplished at a higher temperature, the product would undoubtedly be a Portland cement.

Slag Bricks.—In a previous article[1] I have made a distinction between the terms "slag-bricks" and "slag-blocks." The distinction seems of value and will be restated here. The term "slag-bricks" is applied to those bricks, tiles, etc., made by mixing slaked lime with crushed or granulated slag, molding the mixture by hand or in a brick machine, and drying the product. The term "slag-blocks," on the other hand, refers to the blocks made by pouring molten slag into a mold.

In Europe the manufacture of slag bricks is an important industry, though it has not come extensively into practice in this country. It is usually carried on in connection with the manufacture of slag cement, in which case the only additional requirements are a few machines and considerable floor space. The processes of manufacture may be briefly stated as follows: Slags of approximately the same type as those used in the manufacture of slag cement[2] are granulated, dried and finely ground. The following analyses of slags used in the manufacture of slag brick at various plants are fairly representative; No. 4, however, is peculiarly low in lime, requiring the addition of considerably more slaked lime than usual, and giving a brick that dries and hardens with more than average slowness. Sufficient slaked lime is added to the slag to bring the total lime (CaO) content of the mixture up to about 55%, and the materials are carefully and thoroughly mixed. If the slaked lime has been added in the form of paste, the material is ready for the brick machine. If, however, the slaked lime was a dry powder, it will be necessary to add a small quantity of water to the mixture, in order that it may be sufficiently plastic to form good bricks. On issuing from the brick machine, the bricks are placed on racks to dry, either in the open air or in a drying house. In from 6 to 10 days' time, according to

	(1)	(2)	(3)	(4)	(5)
Silica (SiO_2)	22·5	25·8	27·0	33·0	35·0
Alumina (Al_2O_3)	14·0	17·3	19·3	18·67	15·0
Iron oxide (Fe)	3·3	1·5	1·7	1·0	1·1
Manganese oxide (MnO)	·0	·0	0·1	4·25	0·3
Lime (CaO)	51·0	51·5	51·5	40·0	45·0
Magnesia (MgO)	1·4	0·4	2·5	2·33	Trace.
Sulphur (S)	0·3	1·3	1·8	1·33	0·4

[1] THE MINERAL INDUSTRY, Vol. X., pp. 84-95, 1902.

[2] *Engineering News*, Vol. XLIX., pp. 384, 385, 1903.

[illegible] pouring molten slag into molds. The molds may naturally be of any form so that the slag block can be shaped like a common brick, a tile, [illegible] Slag blocks are made somewhat extensively in the Lehigh [illegible] used as paving material, notably in Philadelphia. They [illegible] objectionable because of their slipperiness. This difficulty [illegible] practice in the Middlesbro district, England, by casting [illegible] mold provided by a projection, which results in a [illegible] the slag block. The two halves of the block after cooling [illegible] a chisel, and the rough fracture surface of each is laid upper [illegible]

[illegible] slag blocks are cast in iron molds, with the top uncovered [illegible] and therefore require little floor space for storage of [illegible] In the best practice, however, blocks are cast in sand, or [illegible] molds which are covered immediately after pouring with [illegible] This treatment allows the slag [illegible] slowly, giving [illegible] and resistant block. More floor space for storage, however, is [illegible] than in the first method.

The Mechanical Equipment of a Modern Portland Cement Plant.

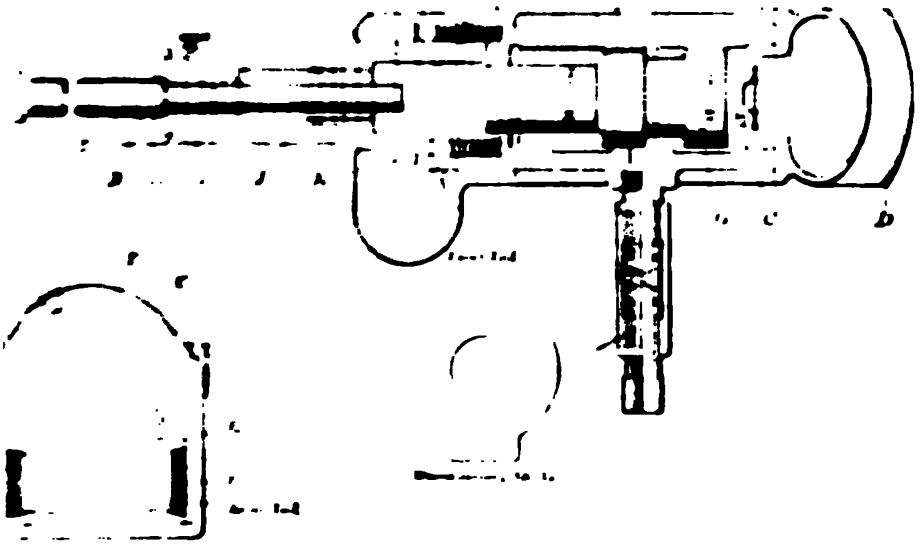
By F. H. Lewis.

The Portland cement industry in America had its beginning in 1875. At that time a small plant was started near Allentown, Pa., by David O. Saylor, employing as the raw materials the so-called cement rock of that section of Pennsylvania which had previously been used in the manufacture of natural cement, and which was brought up to the proper composition for Portland cement by the addition of pure limestone. An exhibit of this cement was made at the Centennial Exposition in Philadelphia in 1876. Saylor was thus the originator of the enormous industry which has developed in this section of Pennsylvania, and in similar rock deposits in western New Jersey since that time. About the same date (1875) Thomas Millen started the manufacture of Portland cement at South Bend, Ind., using the wet process, the raw materials being the wet marls and clays of that section. This factory was afterward abandoned for a new location in New York State, and for twenty years the growth of the industry by the wet way in America was extremely slow. Since 1897, however, there have been an extraordinary number of factories built in the marl sections of Ohio, Indiana and Michigan, making Portland cement by the wet method. Yet it is to be noted that while David Saylor's enterprise has been growing since its inception, and is now a very large plant, none of the original marl plants has expanded by natural development to large industries. The great establishments in the marl regions are all of them new enterprises and not developments from small beginnings.

During the first 20 years of its existence, the cement industry made slow progress, the total product in the United States in 1895 being but 750,000 bbl., 85% of this being produced in Pennsylvania and New Jersey. Since that date, however, the growth of the industry in all sections of the country has been extraordinarily rapid, the total product for the year 1902 being over 16,000,000 bbl. But in spite of this extraordinary growth the proportion manufactured at the point where the industry first began, that is, in the so-called cement rock section of eastern Pennsylvania and western New Jersey, is still 65% as compared with the total production by the wet way of about 15%.

It is probable that there is no place in the world where raw materials of equal quality are found in such abundance as they are in this great Pennsylvania cement section. This district has not only set the pace in manufacturing for the entire country, but the genius of its manufacturers has developed much the greater part of the improvements in manufacturing. The rotary kiln was developed here, as was the method of burning by powdered coal, with all the successful methods of cooling, storing and grinding clinker. These are the features which have developed into a distinctive American practice and have given a basis on which to establish a successful industry.

With expensive labor and comparatively cheap power, the American manufacturer in competing with the European product has been compelled to follow the same lines as those which have been successful in the American iron and steel industry, which is now pre-eminent, that is, the substitution of mechanical de-



These drills are small, readily transported, and by using two or three of them, all the large stone can be broken up with a very small amount of sledging.

A considerable variety of practice has developed in handling the stone between the quarry and the mill. With pit quarries adjacent to the mill the ordinary method is a system of skips running on overhead rope tramways. These have the advantage of lifting and carrying by the same power. A number of these tramways are in use in Pennsylvania carrying stone quite economically. In open face quarries various types of side and end dump cars are used, usually of 3-5 ft. gauge or less, a narrow gauge being desirable for dump cars.

In many cases a crusher outfit in the quarry offers advantages; where practicable and when the handling of the mix will permit, it should always be used. The advantage derived from crushing material at once arises from the fact that it is much more easily handled in the subsequent processes. In some cases, however, as in a number of plants in the Lehigh Valley, this becomes impracticable because the required limestone is purchased from quarries at a distance, and is delivered by rail in standard gauge equipment. Under such circumstances it is generally necessary to handle both stones in bulk at the plant. When both raw materials are found at the factory site the advantage of crushing them at once and handling them through a system of bins and pockets is considerable. It is even a question whether it would not be economical to buy crushed stone instead of lump stone when it is purchased at a distance. The advantage of this would arise from the ease and accuracy with which the mix could be made and sent together through the subsequent processes of reduction.

The size of the quarry, its distance from the mill, its elevation above or below the level of the mill, and the character of the raw materials, all must be considered in determining the methods of quarrying to be used, but in any and every case the largest mechanical installation which is practicable will prove to be the most economical. In this way some type of steam shovel will prove advantageous for handling large quantities of material. The installation of air compressors for drilling will prove more economical than using steam direct, the loss of power from the condensation of steam being much greater than the loss of power in compressing the air. In order to economize still more when using air, some form of reheater for heating the air in the supply pipes at the quarry adds considerably to the efficiency of pneumatic power, and is especially advantageous in the winter time. Cold air in cold weather causes considerable trouble in freezing the supply pipes and the valves on drills. A simple pipe coil installed in some type of furnace will reheat the air satisfactorily.

The cost of quarrying varies considerably, and in this respect the Pennsylvania manufacturers have the advantage over the majority of plants using dry raw materials. The Pennsylvania cement rock is a soft shale, easily blasted, easily sledged, easily handled by the steam shovel, and readily and rapidly broken in crushing machinery. It is handled under favorable conditions in Pennsylvania and New Jersey at a cost varying from 18 to 30c. per ton as compared with the cost of handling the harder limestones varying from 30 to 50c. per ton. Offsetting this advantage in some measure, however, is the comparatively high cost of limestone required to bring the Pennsylvania cement rocks to a normal com-

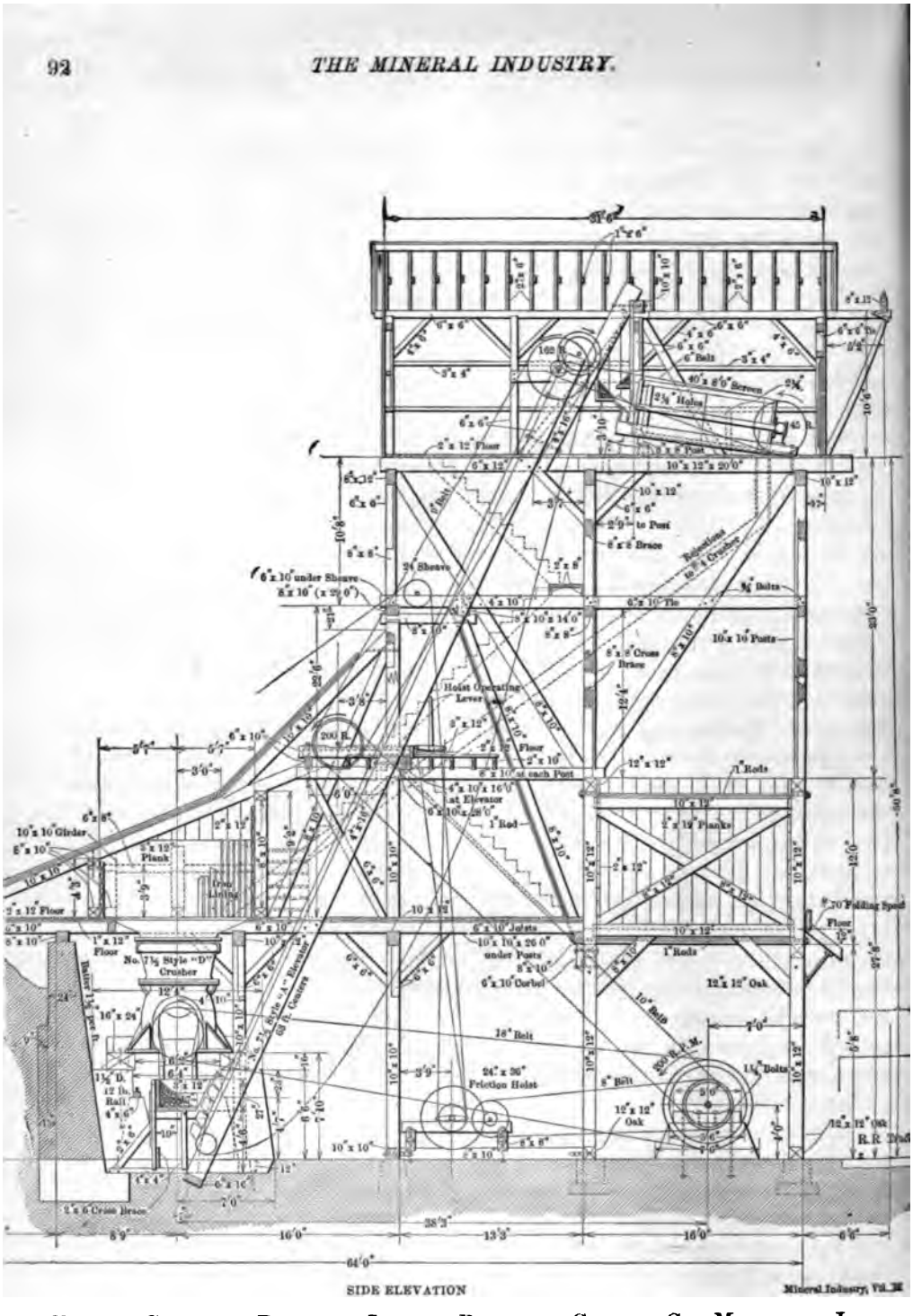


FIG. 2.—CRUSHING PLANT OF LEHIGH PORTLAND CEMENT CO., MITCHELL, IND.

time it leave the quarry at a very considerable saving of labor and cost. With such a plant the separation of the stone by screening after it leaves the crusher is essential because large flat slabs in the mass of the material will always make trouble by the choking of bins and chutes.

For handling the stone, or indeed for handling any lump material, a belt con-

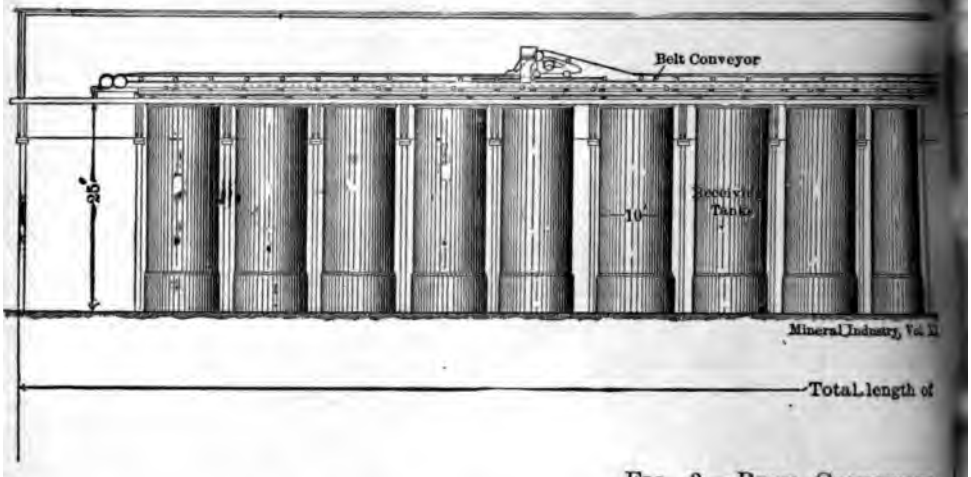
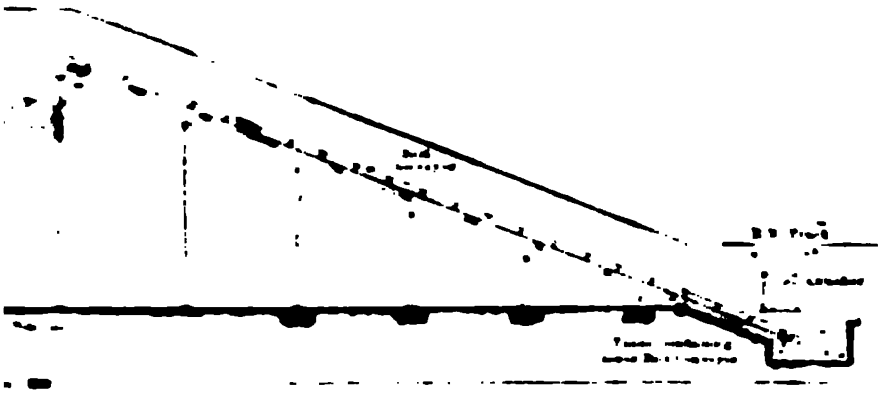


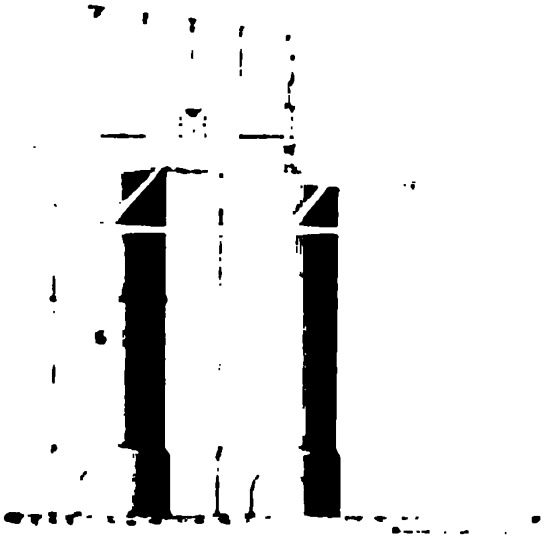
FIG. 3.—BELT CONVEYORS

veyor has proved to be by far the most satisfactory mechanical device. Its cost is very high, but it has great efficiency, and as all parts are visible and accessible at all times it is easily repaired, seldom getting out of order seriously or in a way which cannot be overhauled in the course of an hour or two. Properly installed the best types of belt conveyors will handle crushed stone up inclines as high as 25°. By means of movable trippers the material may be deposited at any point over large areas, or by means of fixed trippers it can be made to deposit at any one of a series of points.

For cement machinery it is necessary that all the moving parts should be thoroughly well constructed and of heavy type. The only difficulty which has been experienced with belt conveyors has been due to the use of light fixtures such as are used satisfactorily in handling grain. An equipment of this kind is poor economy. First class belt conveyors installed in place vary in cost from about $8 a running foot for narrow conveyors up to $25 or $30 for the large sizes, the average cost for a 14-in. conveyor being about $10 or $11, and for a 16-in. conveyor from $12 to $15 per linear foot measured between centers of head and tail pulleys. In the installation shown in Fig. 3 the overhead belt can either carry the material forward directly to dryers or deliver it to the storage tanks as shown on the drawing, or by means of suitable trippers a part can be carried forward to the dryers and the remainder discharged into storage tanks.

The installation of belt conveyors for handling stone in many cases has not been well considered. A belt conveyor necessarily wears much faster in the center than at the sides; hence a belt that is unnecessarily wide costs more to install,





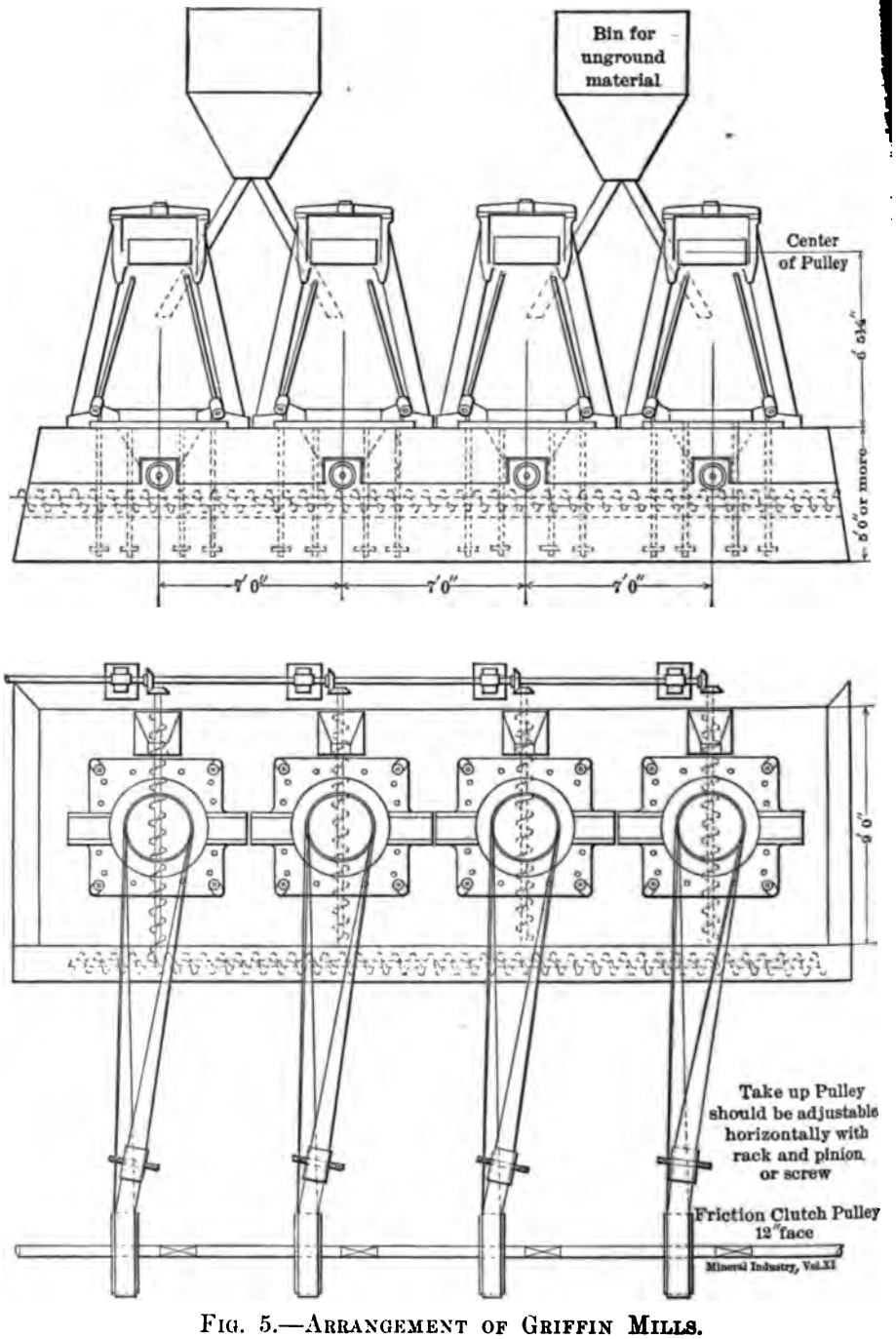
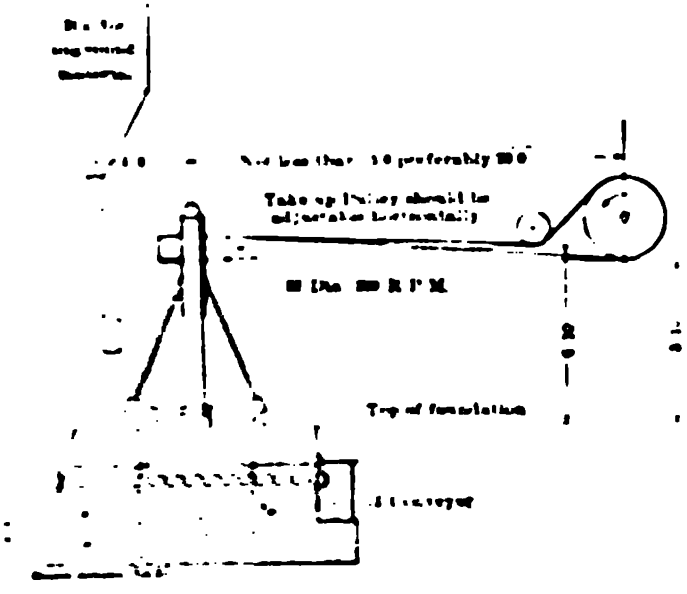
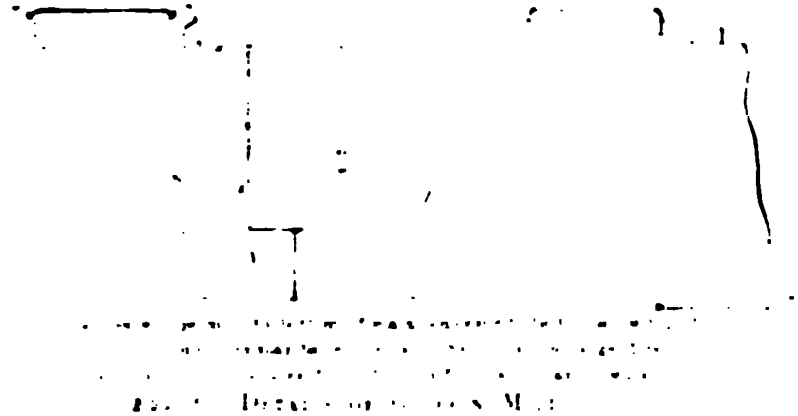


FIG. 5.—ARRANGEMENT OF GRIFFIN MILLS.

and feeding it by some form of mechanical feed
a revolving table under a spout or by any simple





A new type of ball mill introduced two years ago and known as the Kominuter is illustrated in Fig. 7. This mill differs from the ordinary type of ball mill in having a peripheral discharge. The material is fed to it just as it is to a ball mill through a suitable nave adjacent to the shaft at one end of the mill. It can only get out of the mill, however, at the forward end through a series of openings in the periphery of the shell. This makes it necessary for the material to pass from one end of the mill to the other before it can reach the screens. In

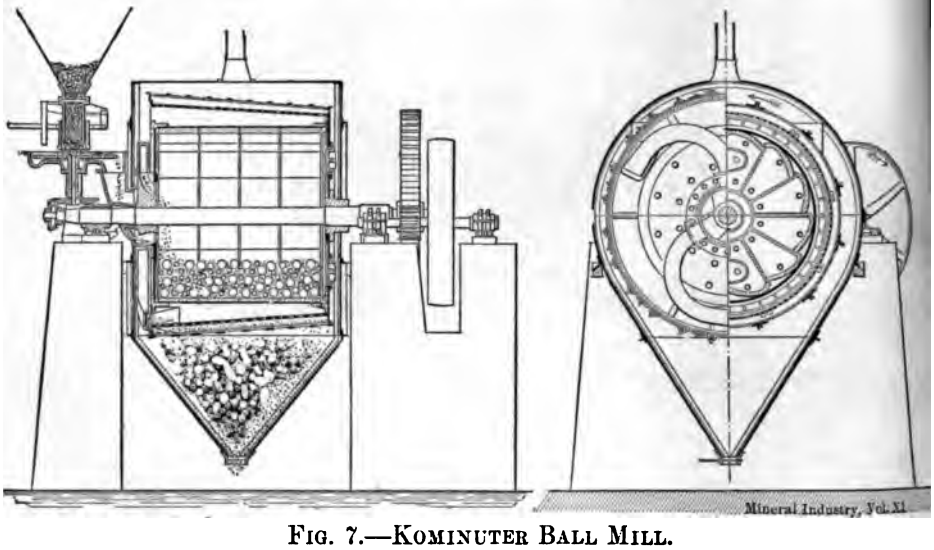


FIG. 7.—KOMINUTER BALL MILL.

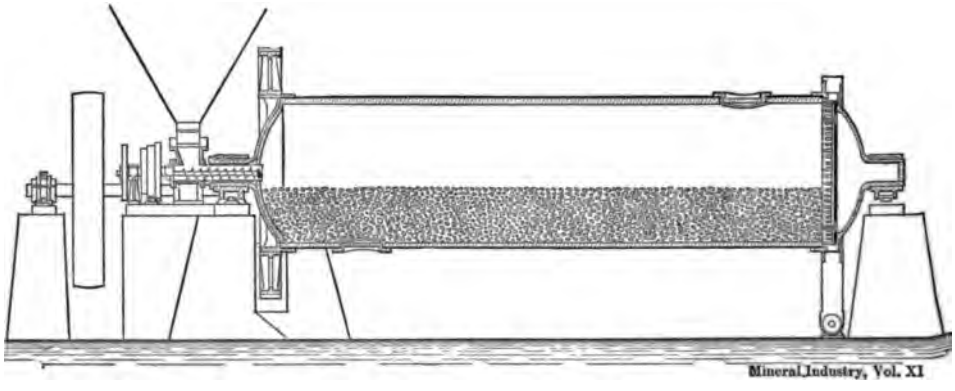
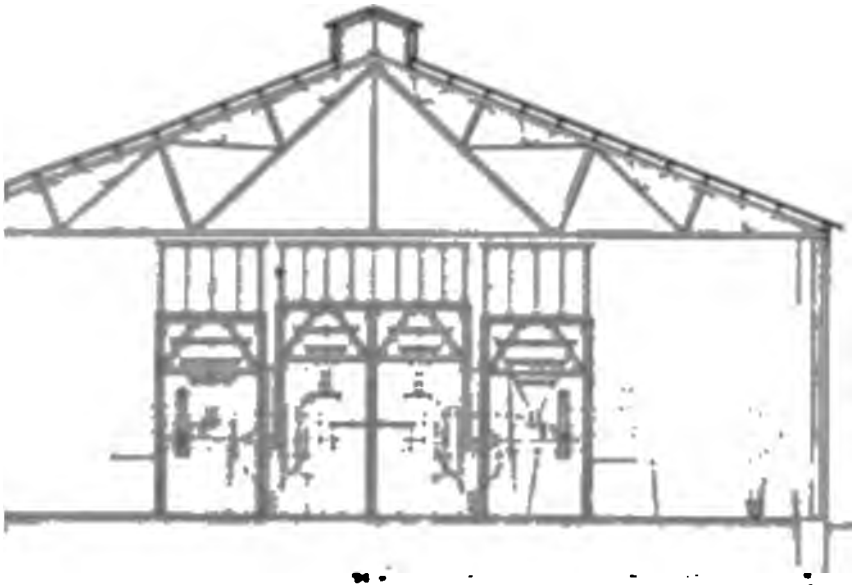
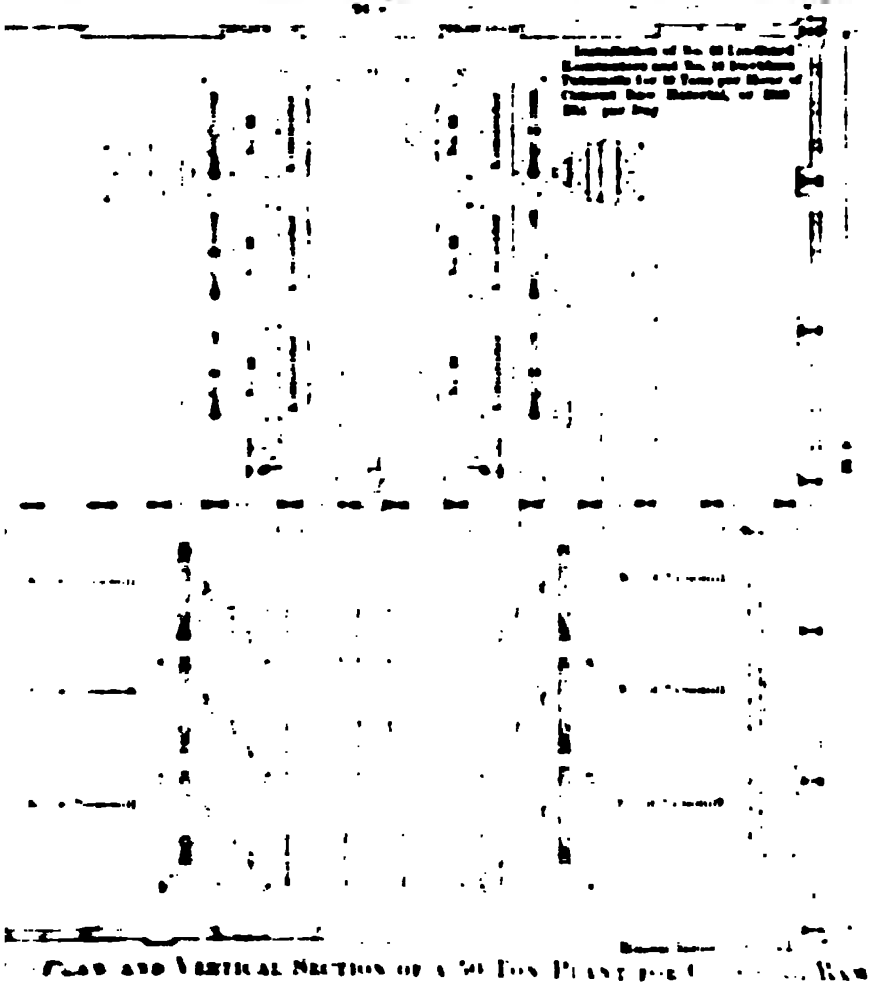


FIG. 8.—TUBE MILL.

the regular type of ball mill, the material passes to the screens freely at all points of the periphery across the mill. The advantage gained by the Kominuter due to this difference, is that with the same output the material will necessarily be finer ground. Passing out of the peripheral discharge of the Kominuter, the ground raw material falls upon an inner screen set at an angle with the mill and must return over this screen to the feed end of the mill, passing in this way over





PLAN AND VERTICAL SECTION OF A [illegible] PLANT [illegible]

MATERIALS

the entire screen before the coarser particles are returned. The return arms are shown in Fig. 7. By means of these arms the material which the screens reject is returned to the mill at the same point where the original feed enters. Ordinarily the Kominuter is equipped with double screens and provided with three

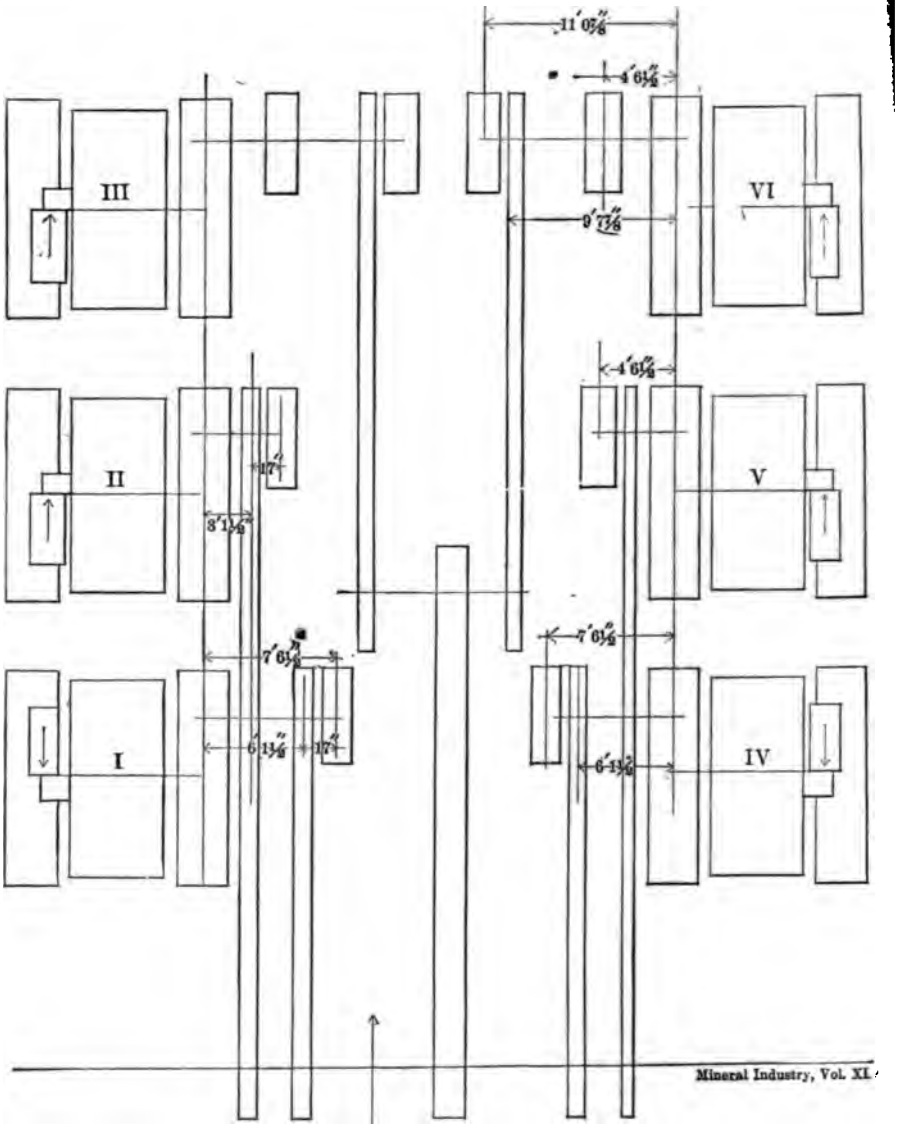
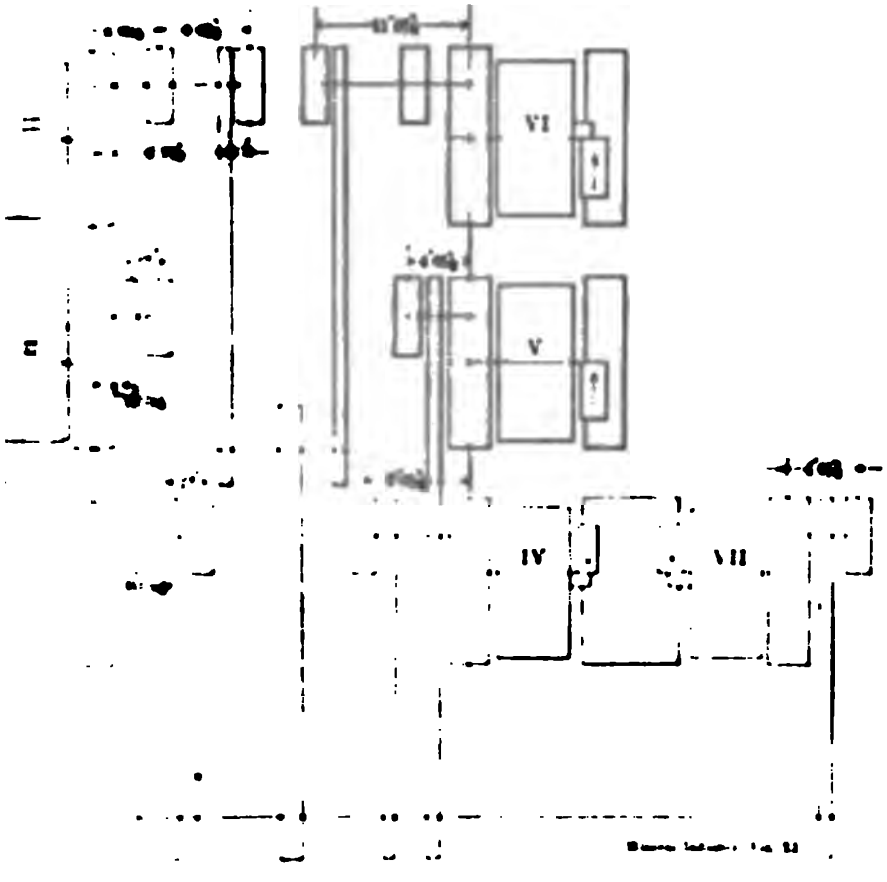


FIG. 10.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

return arms. It can be arranged so that one of these return arms takes the tailings from the inner screens and two of them take the tailings from the outer screens, or vice versa. Or the inner screens can be entirely omitted and all three return arms used to return the tailings from the outer screens. A large number

[illegible] machines have been sold for cement plants within the last two years. As built they are the largest mills of this character on the market, carrying [illegible] more balls than the largest type of regular ball mill.

Fig. 9 [illegible] shown a section of the tube mill made by F. L. Smidth & Co., the firm that manufactures the Kominuter. This particular tube mill also has [illegible] discharge. The principle of this mill, and, in fact, all of them, is [illegible] grinding of material by means of attrition with a large body of flint [illegible] covering the material between the pebbles and in contact with the lining.



Arrangement of Kominuter Ball and Pebble Mill

[illegible] the well known [illegible] flint pebbles and the [illegible]

[illegible] commercial [illegible] of the feed [illegible] a long well put in will last from [illegible] It has also [illegible] a mill of this type which will [illegible] between it and [illegible] raw [illegible] either of raw material or clinker

A complete installation of Kominuters and pebble mills with their feed boxes and the main conveyor systems to carry away the product is shown in Fig. 9. This plan shows a battery of six Kominuters making first reduction of material for a battery of six tube mills. In both batteries there are two large pulleys on the line shaft and two small ones. The middle and the long drive mills are driven direct from the line shaft, while the short drive mill is driven from the counter shaft of the long drive mill. All the pulleys on the line shaft are plain pulleys. Each mill shaft is provided with a clutch cut-off coupling making it possible to throw out any mill without shutting down the line shaft or disturbing operations in any of the other mills.

In Figs. 10 to 13 are shown typical layouts of ball and pebble mills as used in recent modern plants, with their drives from the line shaft of the mill. The illustrations do not require any detailed explanation.

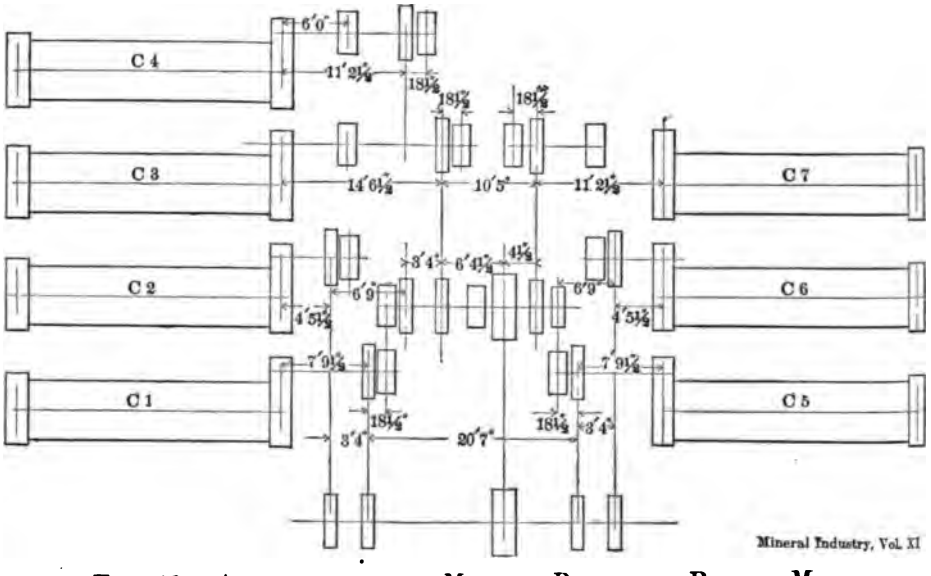


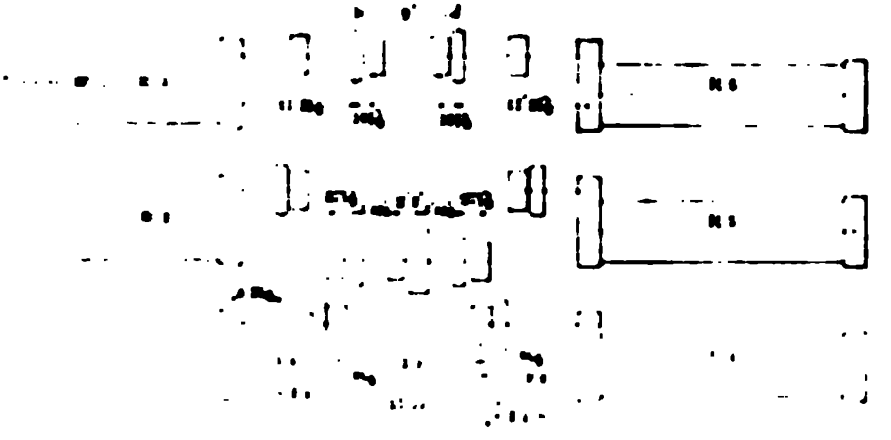
FIG. 12.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

In all grinding of dry raw material, the finer the grinding the better the product. This is axiomatic, but it has a practical bearing from the fact that the finer the raw material is ground, the [illegible]er the clinker and the easier it is to grind. There is a practicable limit [illegible]ings, however, and it is found that a fineness of 80% passing through [illegible]esh sieve will give an entirely satisfactory products in both respects, th[illegible]cement will be homogeneous, and the clinker will be small and readily ground.

Kiln Practice.—For dry materials two types of kilns are used. One the cylindrical kiln of uniform diameter, the other, the taper kiln reduced in diameter at the chimney end. The general arrangement of the second type is shown in Figs. 14 and 15. This kiln has a diameter of 60 in. at the chimney end and 66 in. at the discharge end and a length of 60 ft. It is supported on trunnions on

[illegible] a train of coarse, raw powdered coal and cools the clinker [illegible] a [illegible] table cooler. The inclination of the kiln is 0.75 in. to 1 ft. [illegible] as a standard kiln for dry raw materials. A large number of [illegible] the same general arrangement are in use in the Lehigh Valley in [illegible]. The arrangement in plan is shown in Fig. 14, which illustrates [illegible] a [illegible]. The cylindrical kiln, which has met with most favor, is [illegible] 60 ft. long, supported at two points on trunnions and is [illegible] 9 ft. in diameter. This kiln is more readily lined than the other kiln [illegible] as satisfactory results, but theoretically the taper kiln [illegible] advantages. A cylindrical kiln in plan and elevation is [illegible] Fig. 13.

[illegible] and shorter than the kilns described have been used. Within [illegible] a [illegible] have been built having a length of 45 ft., and in a new



[illegible]

[illegible] of [illegible] Plant [illegible]

[illegible] general. The more effective it is in the [illegible]

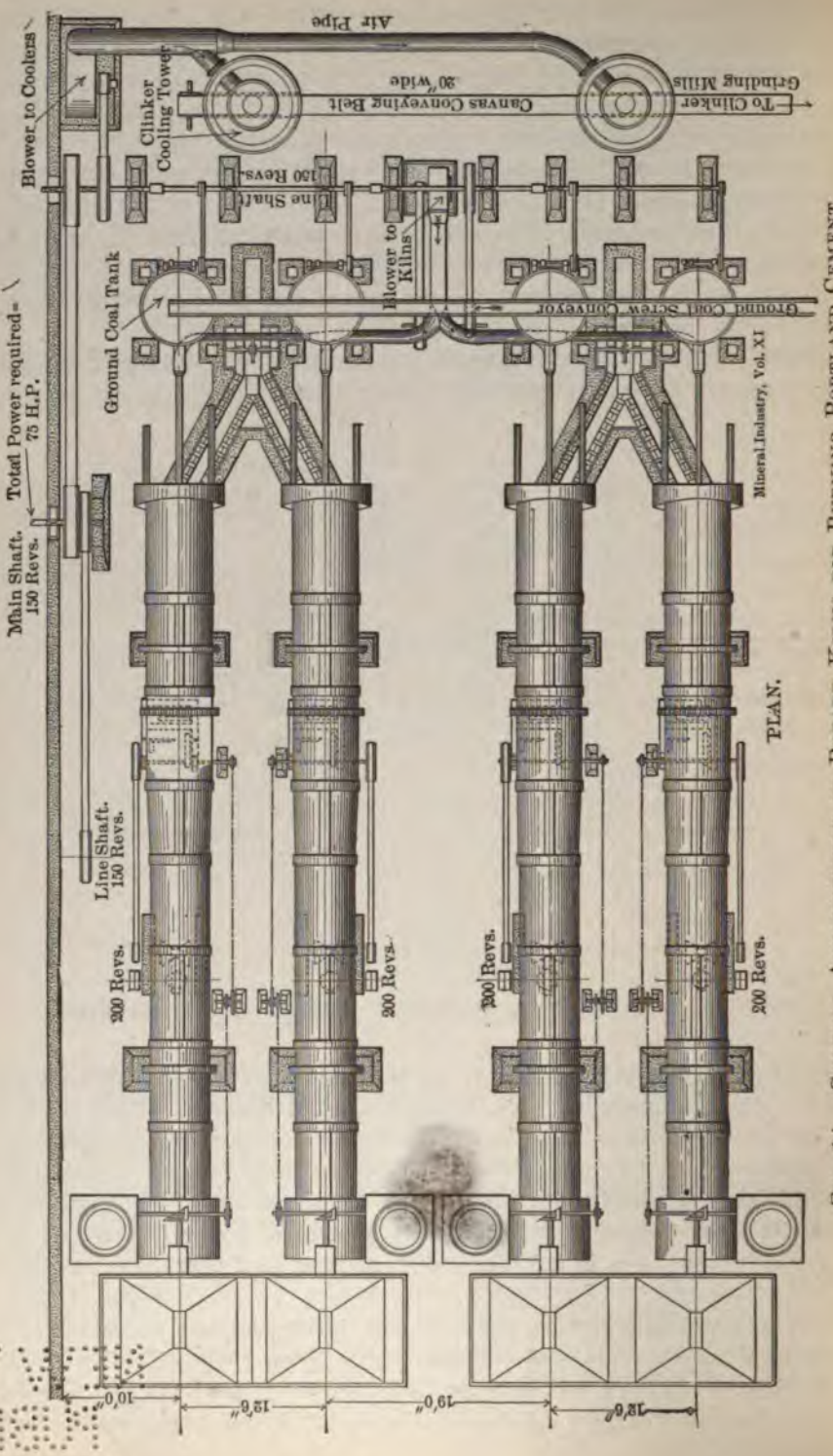
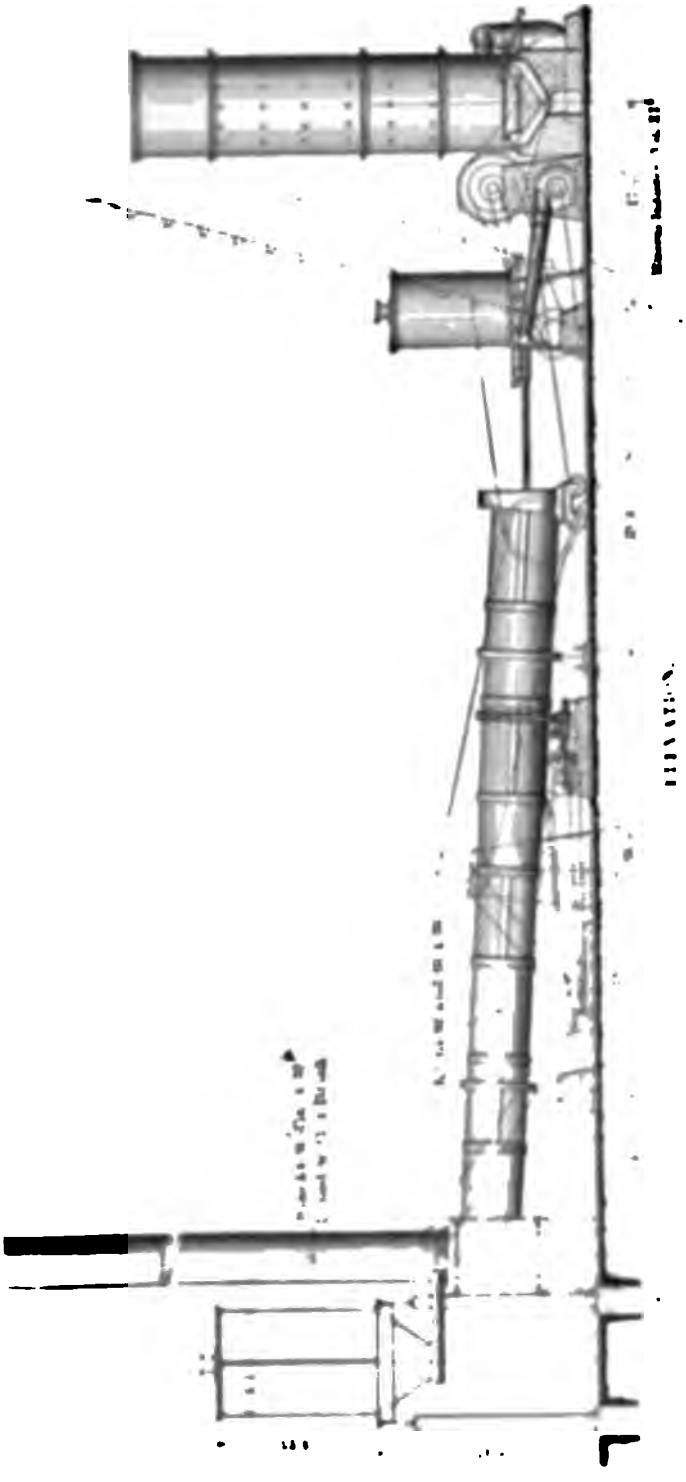
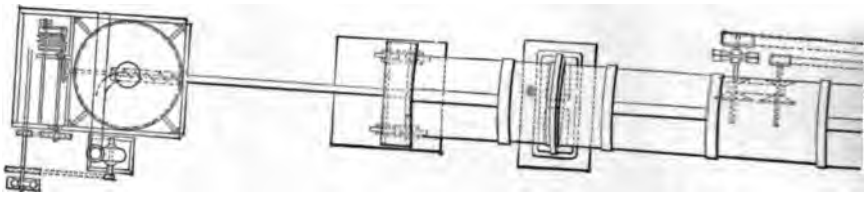
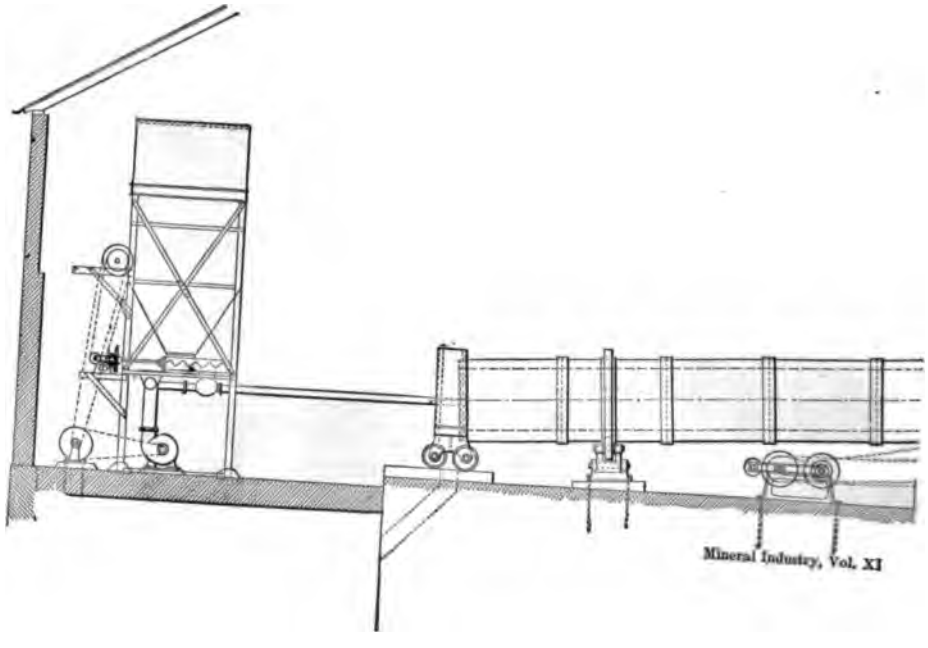


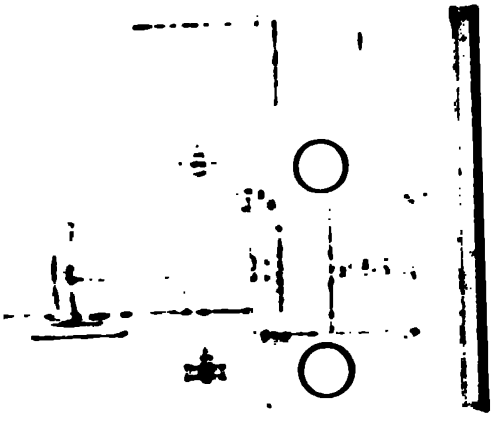
FIG. 14.—GENERAL ARRANGEMENT OF ROTARY KILNS FOR BURNING PORTLAND CEMENT.

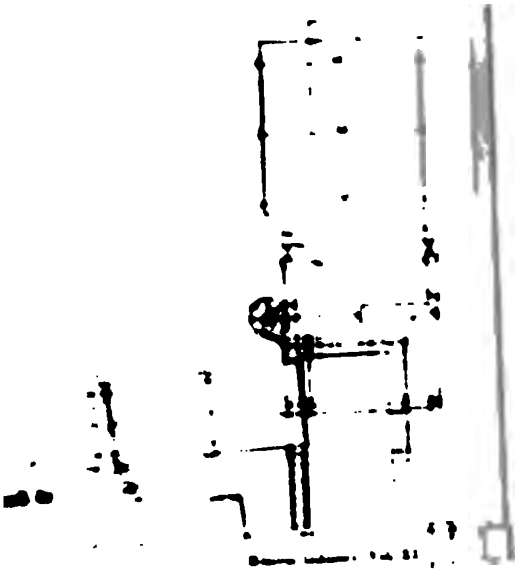


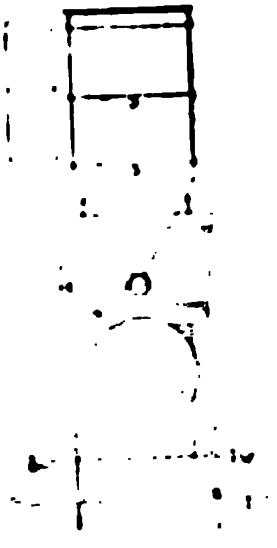




FIGS. 16 AND 17.—CYLINDRICAL







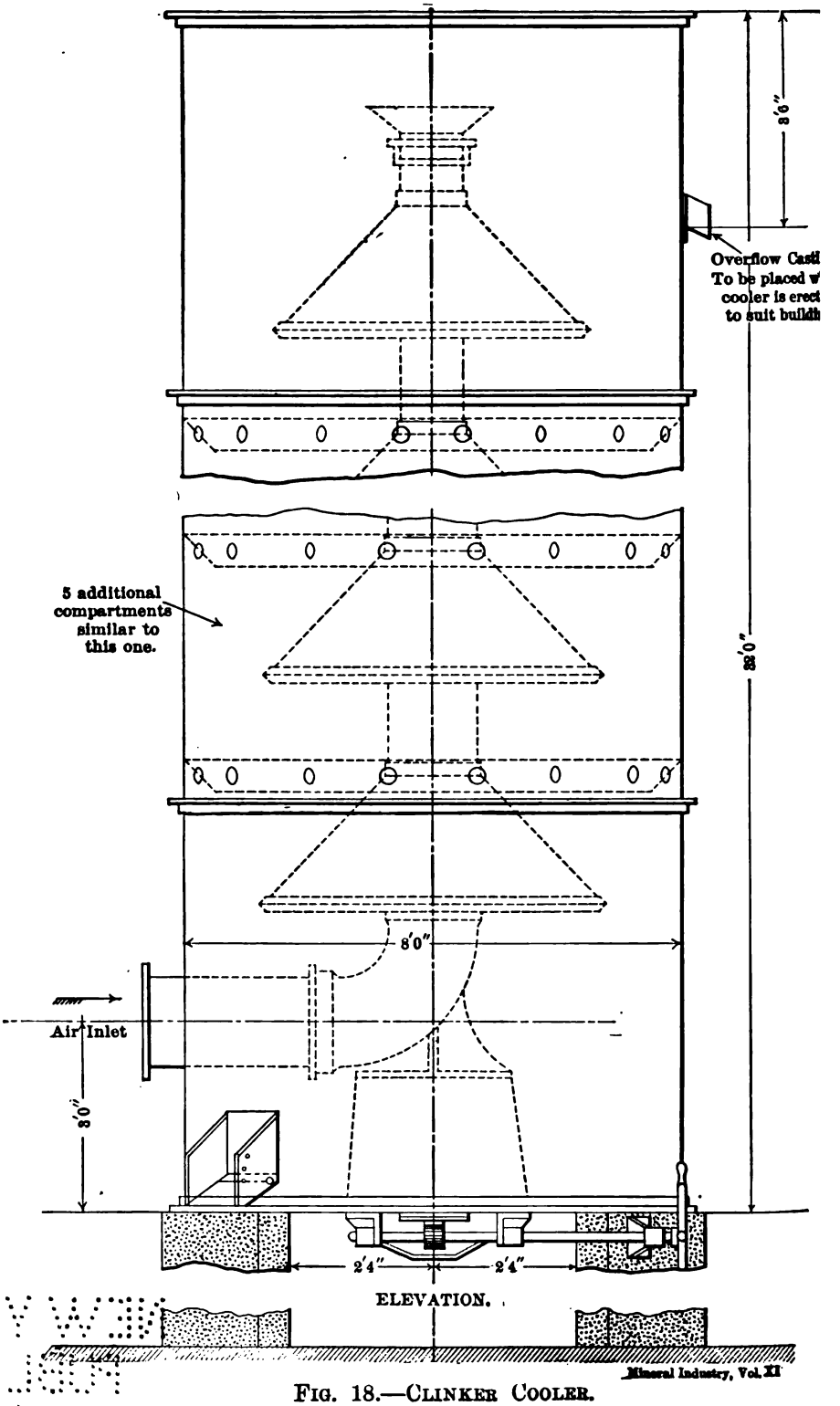
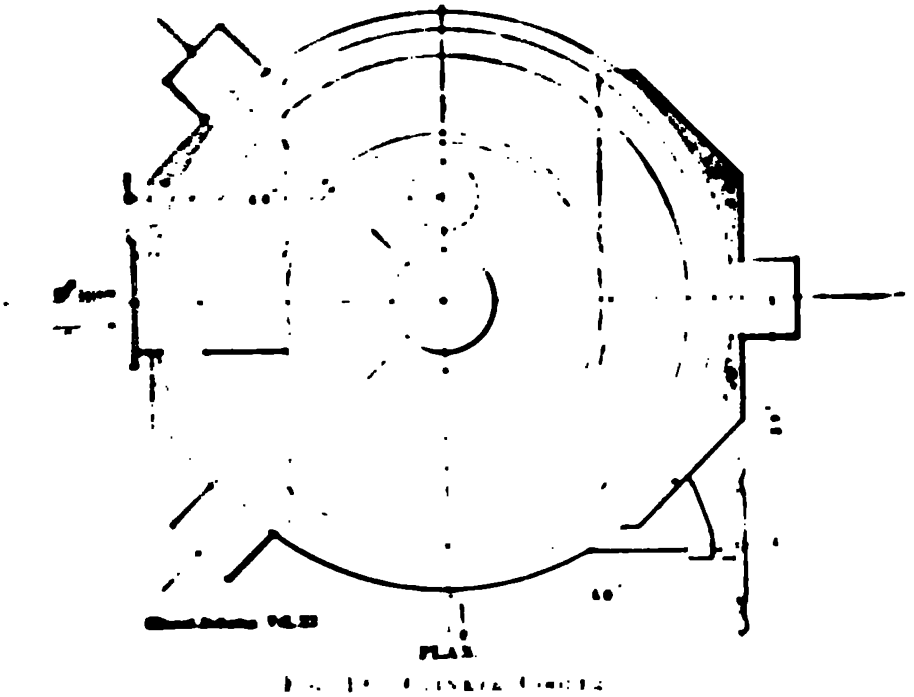


FIG. 18.—CLINKER COOLER.

the output the smaller the coal consumption. A 6-ft. kiln will yield in cement [illegible] to 20 bbl. of clinker per hour, or 5 bbl. being a very good average performance.

The most difficult problem in rotary kiln practice has been the handling of the clinker. A great variety of devices have been experimented with for this purpose. In modern plants it is customary now to wet the clinker by a water spray to reduce the temperature, and to complete the cooling by means of an air blast blown through the clinker in a suitable constructed tower. In Figs. 18 and 19 is shown a clinker cooler tower of this type. By referring to Fig. 14 a tower of this kind will be seen as a part of the general arrangement of the kiln building. A bucket elevator conveys the hot clinker to the top of the clinker cooler tower. In the tower the height of the clinker is maintained up to or above the top of the air



PLAN.

[illegible]

[illegible] in Fig. 19, [illegible] at the top of the tower [illegible] and [illegible] from the top to the bottom [illegible] cooler tower such as shown in the [illegible] will [illegible] of water [illegible] and [illegible] This tower has a suitable [illegible] have run to convey to some suitable [illegible] The material at the bottom can either be drawn [illegible] while discharging on a belt conveyor.

A tower of this description will cool the clinker so that it can be readily and safely handled and ground. The fact has developed incidentally, however, that clinker which has been thoroughly cooled during a period of from 1 to 10 days grinds much more readily than the clinker discharged from a cooler at 97°F. within 6 or 8 hours after it has left the kilns. This fact has developed by reason of the occasional necessity for accumulating clinker due to the breakdowns in clinker mills, or for any reason which has made it impracticable to grind the clinker at once. In several recent plants, therefore, advantage is being taken of this fact, and, instead of running the clinker direct from the coolers to the mill, it is carried first to a suitable building where it can be stored and seasoned. It is found that clinker treated in this way will grind from 20 to 50% more rapidly in ball and pebble mills than fresh clinker. If this claim is established, it will evidently justify large expenditures for clinker storage facilities. The cost of the clinker storage building might be even greater than the cost of the mills required to grind the hard, fresh clinker, but as it would take very little power to operate a clinker storage building as compared with a large amount of power to operate mills, the clinker storage system more than justifies itself. Hard burnt, fresh clinker will often scratch glass, and is extremely hard to break up. Well sprayed with water and stored for some days it breaks up very readily, and has lost a good deal of the sharp cutting quality of fresh clinker.

Wet Raw Materials.—The handling, grinding and burning of wet raw materials differs in many important particulars from similar operations with dry raw materials. After passing the kilns, however, the processes are essentially the same and can be treated under one heading. For this reason the present article deals briefly with wet raw materials under the present heading up to the time they are clinkered.

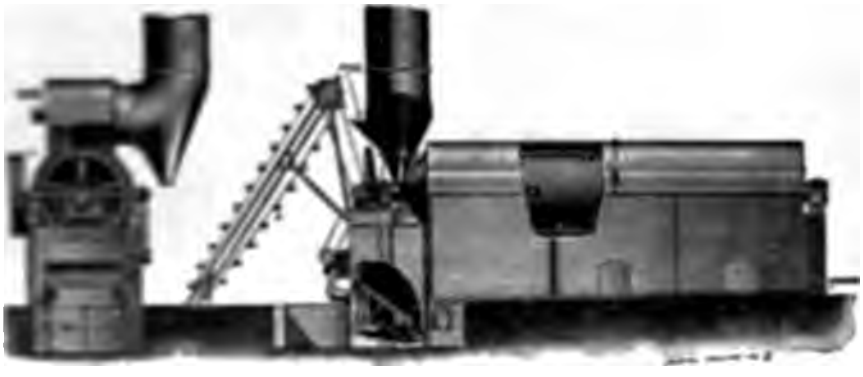
It cannot be said that any practice has been established in the handling of wet raw materials. The reason for this arises from the great diversity in the character of these wet raw materials. In some cases the lime and clay rocks are both soft, homogeneous materials, free from sand, shells or any hard particles. Such conditions are, however, comparatively rare in this country, the majority of the wet raw materials containing either shells, sand or some form of gritty material which must be reduced as well as mixed. In the first case a simple mixture is required which can be accomplished in some form of wash mill or tank in which the two materials can be stirred together in the presence of a proper quantity of water. In the other cases it is necessary to do more or less wet grinding. Owing to the presence of the water, this wet grinding is difficult to accomplish. An ordinary pebble mill will not do it because the pebbles lose so much in gravity by being immersed in water. Steel balls have been substituted for pebbles with a satisfactory result. In each particular case, however, the problem has to be solved to suit the materials. The aim of all plants manufacturing Portland cement from wet raw materials is to get them into a homogeneous mixture, finely ground, and with a minimum of water.

Undoubtedly, when materials can be brought to a finely divided state, and to an intimate mixture in the presence of water, no better mix of Portland cement could be desired. But the practical difficulties of doing this, with a very large

steadily the expense of this feature of cement manufacturing. The standard fineness for Portland cement was formerly 95% passing a 50-mesh sieve or 85% passing a 100-mesh sieve. This represents good practice abroad to-day. But in American specifications the tendency has been to push these requirements for fineness up to 90%, 92%, and even in a few instances to 95% passing a 100-mesh sieve. The practical advantages of this excessive fineness are not apparent, while the increased cost of manufacturing both in power, equipment required and repairs are considerable. It is true that the material rejected by a 50-mesh screen is probably inert, and so is a part of that rejected by the 100-mesh. But as it has been repeatedly demonstrated that 35% or 40% of absolutely inert material such as sand, ragstone, cinders or limestone can be ground with cement with comparatively small effect to its strength or its capacity to carry sand in mortars, the argument for excessive fineness is weak. In speed it is the last knot, or the last mile per hour which costs in power, and a limit may be reached which can only be surpassed at a cost which is prohibitive. Precisely the same thing occurs in grinding. The difference in output between a mill grinding 88% fine, and one grinding 95% fine is often 100%. And for any specification requiring over 90% fine it becomes necessary for the manufacturer to consider carefully ways and means of accomplishing the result. The readiest expedient is to raise the percentage of lime in the cement. The higher the content of lime in a cement mix the more refractory it is in the kiln. A high lime clinker is, therefore, softer, less vitrified, less "clinkered," in fact, than a lower lime clinker, and it is in consequence more readily ground. Within limits such clinker produces satisfactory cement for most purposes. Yet while each increase in the content of lime renders the clinker so much easier to grind, it must be borne in mind that the cement is so much higher in tensile strength, so much slower in set, so much nearer the limit where unsoundness may be manifested sooner or later.

Mechanical separation, either by screens or by air, suggests itself as a remedy, but it seems to be a fact that rotary kiln clinker does not lend itself readily to such treatment. At all events no considerable practice has developed along these lines, and cement grinding is for the most part simple mechanical reduction, as here indicated.

Coal Grinding.—Coal for cement kilns must be gas coal having over 30% volatile matter. The high grade steam coals with low volatile matter and high percentage of fixed carbon do not ignite readily enough and burn too far back in the kiln. It is claimed that a homogeneous mixture of gas coal and steam coal will give good results, and this is quite possible. The portion of gas coal igniting freely should burn the steam coal with it, and perhaps even with advantage over gas coal alone. The point is, however, that the presence of high-grade gas coal is always dangerous, as it is subject to spontaneous combustion. By slow oxidation it gradually becomes heated until it smoulders or bursts into flames. In a finely powdered condition this tendency is much more marked than in the lump coal. Spontaneous combustion results very readily, and more or less fire in the coal mill and storage tanks is to be expected, must be provided for and the necessary precautions must always be in evidence to handle the coal without danger. These precautions are based on one important fact, namely, that while



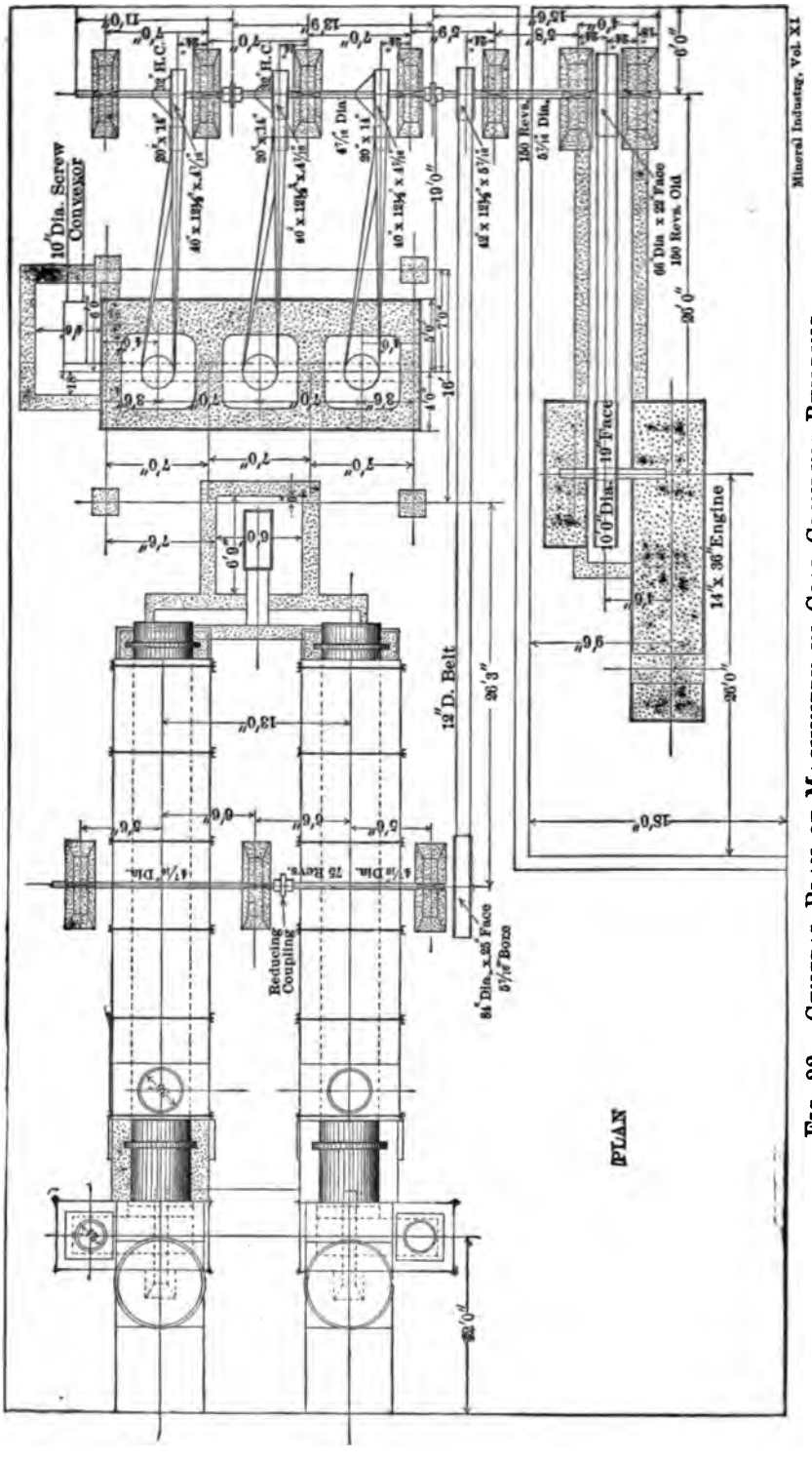


FIG. 22.—GENERAL PLAN OF MACHINERY IN COAL GRINDING BUILDING.

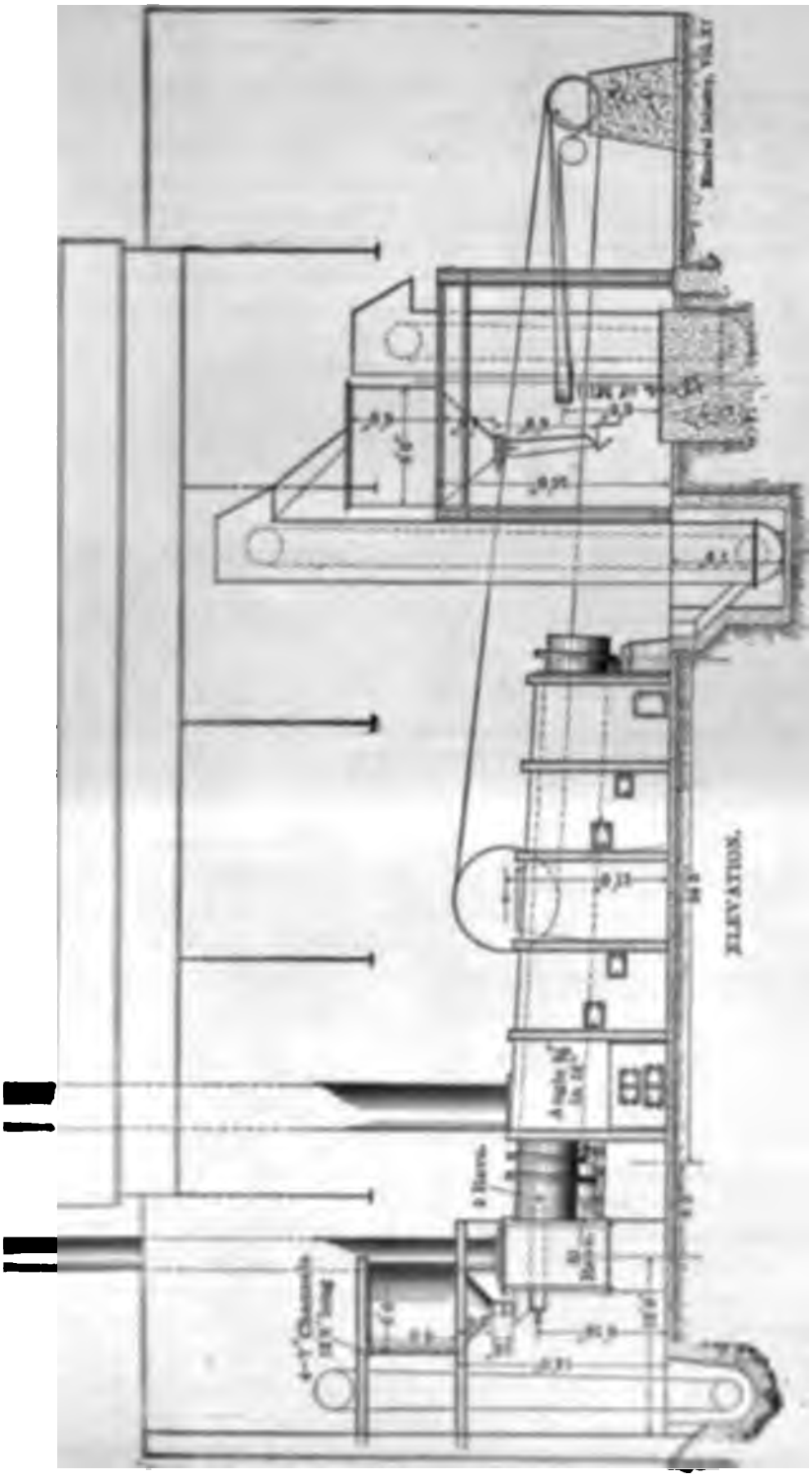


FIG. 71.—SIDE ELEVATION OF MACHINERY IN COAL GRINDING BUILDING.

1903 at a plant in New Jersey where a system of air separation had been installed.

Packing and Shipping.—When ground from clinker which is entirely cold, cement powder on leaving the mills has a temperature between 125° and 150°F. The increase above normal atmospheric temperature is due entirely to the friction of the grinding process. If the clinker is not cold, the cement powder leaves the mills at still higher temperatures. The problem of storing cement in bulk so as to remove this heat has received a great deal of attention with very small results. If it could be accomplished a considerable advantage to the product would result. Cement in bulk undoubtedly does season and cool somewhat, but in masses of 1,000 bbl. and upward the process is slow. The best opinion, there-

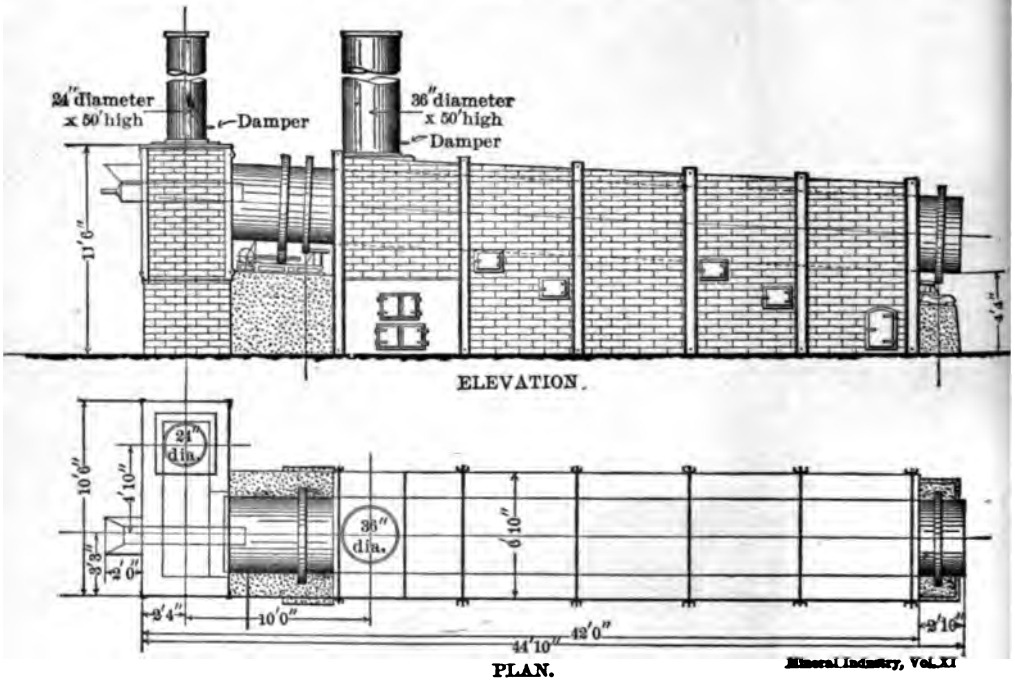


FIG. 21.—COAL DRYER.

fore, favors seasoning the clinker, rather than the cement, and this feature is receiving the most attention.

The heat of the cement, its avidity for water and its weight prove destructive to barrels, and no material is harder on this kind of package. The present standard cement barrel has 28·5 in. cylinder, sawed staves 0·4375 ($\frac{7}{16}$) in. thick sawed with 0·625 ($\frac{5}{8}$) in. bilge. The head is 16 in. in diameter and 0·5 in. thick. Eight elm hoops are usually used, though for heavy service two more hoops are added of metal or elm. Such a barrel weighs from 20 to 24 lb.

The ordinary cement stock house is a hot and dusty place. Barrel packing is done mechanically by a variety of machines, all on the principle of a revolving nave pressing the cement into place as it issues from the bin. Bag packing, which

[illegible] to the to parking rooms Shovels, hoes and wheelbarrows are the [illegible] used to get the cement from the bins into the conveyors The reason [illegible] to [illegible] handled here mechanically is that the increased cost of a [illegible] is not justified by the saving effected in handling. [illegible] of systems of conveying systems with tunnels, etc., is great, and the [illegible] are a serious item

In [illegible] it may be said that American practice has dealt fairly well with [illegible] between the quarries and the stock house Between the [illegible] and the point of shipment, large output and a minimum of labor [illegible] work features are the essential ones for success in any manufacture [illegible] conditions It is possible that quarry and stock house work [illegible] successfully developed along the same lines In the meantime it [illegible] that the industry could grow twenty fold in eight years without a [illegible] new could an industry advance in this short time from comparative [illegible] to the first place among the natures of the world without genius [illegible]

CHROMIUM AND CHROME ORE.

By Joseph Struthers and Henry Fisher.

The output of domestic chrome ore in the United States is but a small fraction of the total consumption, the great bulk of which is supplied from Turkey. While chromite occurs in California and North Carolina, the combined cost of mining, treatment and transportation to Eastern chemical works is greater than the cost of the ore abroad plus the ocean freight to the seaboard works, and as there is no duty on the ore, the development of the mines in the United States is necessarily hindered. During 1902 the chrome ore mines in California contributed the entire domestic output of 315 long tons, valued at $4,725, as compared with 498 long tons, valued at $7,740 in 1901. The value of chrome ore varies with the content of Cr_2O_3 and silica. The standard ore is 50% Cr_2O_3, and the price is increased from 75c. to $1 per long ton for every unit of Cr_2O_3 above 50. While no fixed premium or penalty is given for the silica content, ores containing small quantities of this component command higher prices. The average price of the domestic chrome ore sold during 1902 averaged $15 per long ton. The imports of chrome ore during 1902 amounted to 39,570 long tons, valued at $582,597, as compared with 20,112 long tons, valued at $363,108 in 1901.

Despite the increased use of ferrotitanium and ferrotungsten for purposes previously filled by ferrochromium, the production of the last-named alloy showed no decrease during 1902 as compared with 1901, the Willson Aluminum Co., with mills at Kanawha Falls, W. Va., and Holcombs Rock, Va., reporting an output of 1,200 long tons of ferrochromium for each year. There has been no radical change in the technology of chrome ore and chromium compounds during the past year (details of which are given in The Mineral Industry, Vols. IX. and X.), although the use of chrome-steel rails is noteworthy. The Pennsylvania Railroad is experimenting with chrome-steel rails at a portion of the road subjected to the extreme service of heavy trains and sharp curves. The alloy used in the manufacture of the rails consists of Cr 50% and Ti 7%, and the percentage of chromium in the finished rail is said to be within the limits of 0·75% and 1%. The Baltimore Chrome Works has been reported sold for $1,000,000 to the Kalion Chemical Co., of Philadelphia. This company supplies

cases the critical commercial point, the extra expense of the combined method of treatment will doubtless be more than offset by the increased values obtained. There was no production of chrome ore in Newfoundland during 1901. A quantity of 83 tons of ferrochromium was shipped from Buckingham, where this product is manufactured.

Greece.—The production of chrome ore in Greece in 1902 amounted to 11,680 metric tons, valued at $140,160, as compared with 4,580 metric tons, valued at $47,770 in 1901. The chrome ore exported from the magnesia district in 1902 amounted to 10,750 tons, valued at $40,310, as compared with 4,750 tons, valued at $16,310 in 1901.

New Caledonia.—The production of chrome ore in 1902 was 10,281 metric tons (value not stated), as compared with 17,451 metric tons, valued at $189,200 in 1901. At Baige N'go where the greater bulk of the New Caledonian chrome ore has been mined of late years, some of the mines have been closed on account of the poorness of the ore, and the production of the remaining mines has been considerably reduced. One or two mines have been opened recently at Nehoue in the Gomen district on the northwest coast, from which good results are expected. A combination of chrome interests among important chrome mine owners is projected, and should it take place an increased output of this ore may be expected in the near future. The mines in question are far in the interior, and the cost of transportation is large. Two French mining companies owning about 40,000 hectares (1 hectare=2·471 acres) have combined to form the Société de Chrome, capitalized at 3,800,000 fr. The company is developing three mines, one in the South Bay, the second in Plum, and the third on Mt. Thiébaghi. The ores contain from 50 to 56% Cr_2O_3. The deposit at Thiébaghi is leased to another company, which contracts to mine a minimum of 10,000 tons, and to pay a royalty of 15 fr. per ton. The mines on the South Bay are said to be especially rich. A railroad is projected to connect the South Bay with the best port of New Caledonia. A large quantity of ore has already been obtained from the Plum mine, and when the necessary arrangements have been made, it will undoubtedly continue to yield a large output. Unsorted chrome ore is worth from 45 to 50 fr. per ton at the mine, and from 54 to 56 fr. at the port of Noumea. A premium of 2·5 fr. per ton is allowed for each unit of Cr_2O_3 above 50%.

New South Wales.—The exports of chrome ore from New South Wales during 1902 were valued at £1,740, a large decrease when compared with 2,483 long tons, valued at £7,774 in 1901; almost the entire output was mined at Gobarralong. At the chromite deposit at Bowling Alley Point in the Nundle division, the ore occurs in pockets in serpentine and is similar in characteristics to the Gundagai ore. A few tons which were assayed at Sydney were reported to contain 47% Cr_2O_3. The great distance of the deposit from the railway rendered the profitable treatment of the ore very uncertain, although if a proper method of ore concentration were installed the deposit might be operated successfully.

New Zealand.—The exports of chrome ore produced by the miners near Croixelles Harbor, during 1900 amounted to 28 tons, valued at $550; there was no production in 1901.

[illegible] The most important deposits of chromium ore are at Roma, but [illegible] the mines suffered from a strike which lasted from March until [illegible] of the year.

[illegible] The exports of chrome ore from Turkey from March 14, 1901, to [illegible] (Turkish year 1317), were 18,252 tons, as compared with [illegible] tons for the previous year. Of this total the European provinces [illegible] Kossovo and Monastir produced 11,650 tons, and the Asia Minor [illegible] Konia, Adana, Angora, Brousa, and Dagharli produced 27,102. [illegible] The principal ore deposits are near Salonica, Brousa and Macri. A rich [illegible] has been exploited exists at Ismidie, the ore assaying 56%. [illegible] Brousa mines have been developed recently, most of the output [illegible] to the United States. The Dagharli mine, which has a yearly out- [illegible] of 15,000 tons of from 51 to 55% chrome ore, exports about [illegible] of its output to the United Kingdom, the balance being divided about [illegible] between America and Germany. The entire output of the Guzelen mine [illegible] to the United Kingdom. There are three chrome mines in the [illegible] of Brousa the Ustaram, Ordendja, and Miran, which together produce [illegible] tons of ore annually. The concessions from these three [illegible] as well as the Guzelen and Bastelen mine, are held by the English firm [illegible] & Co. at Smyrna. The Bastelen mine exports about 1,500 tons of [illegible]. The Turkish government taxes chrome ore 20% and imposes a [illegible] charge of 1%. The total cost at the coast is $8.75 for Macri ore, and [illegible] for Brousa ore. For the past two years the Government has granted no [illegible] concessions and permits the shipment of only 2,000 tons of ore from [illegible] where a quantity of ore has been mined a new permit to continue [illegible] is issued.

Technology

[illegible] a number of analyses and former German patents on the manufacture [illegible] and chrome alum, and will be of interest to those [illegible] should be made to THE MINERAL INDUSTRY, Vols. VIII,

[illegible] Metallic Chromium. The electrolysis of chrome ore prepared [illegible] was described when examined by T. Ibbotson gave the following [illegible]

[illegible]	Iron	Aluminum	Silica
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible] The following shows varying conditions of Mn, Ni, P and C(?) [illegible] concentrated HCl with [illegible] of hydrogen gas. The [illegible] was heated [illegible] with the sample [illegible] the weighed quantity of impurities. The [illegible] produced was [illegible] the reaction being complete when the temperature of the

[illegible]

solution reached 20°C., but was incomplete at 100°C. This change is due to the catalytic action of SiO_2, produced by the solution of the silicon contained in the chromium, in the presence of HCl, and does not take place when the acid is absent.

Duty on Ferrochrome.—According to a decision of the Board of General Appraisers ferrochromium is dutiable at the rate of $4 per ton by its similitude to ferromanganese, and is not dutiable as a metal unwrought.

Chrome Solutions for Tanning Leather.—Chromium compounds[2] for tanning leather were used as early as 1856, but early experiments were not successful as the tannage was not permanent. The discovery of sodium thiosulphate to make the tanning permanent was due to W. Zahn who patented his process in the United States on June 28, 1888. The process consists in dipping the skin in a solution of a chromium salt, acidified with HCl, and then into a solution of $Na_2S_2O_3$ or $NaHSO_3$ acidified with HCl or H_2SO_4. For tanning 100 lb. of skin, 4 to 5 lb. $K_2Cr_2O_7$, 2·5 to 4·5 lb. HCl, 8 to 10 lb. $Na_2S_2O_3$ and 0 to 1·5 lb. H_2SO_4 are required. A number of electric processes for tanning skins with chromium salts have been patented in the United States.

The Use of Hydrazine Sulphate in Analytical Methods.—W. Herz[3] recommends the use of hydrazine sulphate in the estimation of chromates. On adding an excess of solid hydrazine sulphate and gently warming, the chromate is reduced in a few minutes, and on the addition of ammonia the chromium is precipitated as chromium hydrate.

The Allgemeine Thermitgesellschaft at Essen, using the Goldschmidt process, manufactures carbon-free chromium containing from 98 to 99% Cr, which is utilized in steel works to make hardened tool steel, of a chromium content amounting to from 5 to 7%; occasionally tungsten also is added. Carbon-free chromium is extensively used also for making chrome steel of a smaller chromium content to be utilized chiefly in the manufacture of cannon, locomotive bolts and rivets.

[2] Twelfth Census of the United States, 1900, Vol. X., Part IV., p. 588.
[3] *Berichte*, 35, 4, 949.

CLAY.

PRODUCTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1900. (IN THOUSANDS.)

States.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.		Paving Brick.		Other Clay Building Material.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.
Alabama	50,700	$294,060			e 6,760	$141,960			e $1,00
Arizona (e)	10,000	70,000	125	$1,750					
Arkansas	45,000	281,250	e 5,000	55,000					
California (e)	130,000	650,000	3,000	60,000					
Colorado	42,520	245,980	21,296	222,818	2,092	35,563	1,338	$13,381	75
Connecticut	141,381	709,403	7,000	63,000					65,00
Delaware	13,650	87,019	2,625	26,250					
Dist. of Columbia	90,000	760,000	3,150	56,400					
Florida	35,120	210,000							
Georgia	199,043	977,960	4,874	58,409	e 2,200	26,400	4,861	17,043	e 65,00
Idaho	18,107	129,804							
Illinois	476,350	2,581,817	17,008	87,856	9,519	81,078	190,156	1,639,191	784,76
Indiana	392,320	2,126,374	15,123	138,351	3,762	37,622	65,921	662,321	e 350,00
Indian Territory	4,000	20,000	500	5,000					
Iowa	244,804	1,494,803	11,409	101,287	206	2,361	30,002	220,455	60,38
Kansas (e)	50,000	300,000	8,000	60,000	700	6,300	30,000	240,000	
Kentucky	128,641	666,456	6,500	39,000	28,000	290,000	3,000	18,000	130,00
Louisiana	114,285	338,915	9,600	76,800			5,000	30,000	5,00
Maine	115,000	618,700	2,325	18,800			150	1,200	
Maryland	233,517	1,451,479	9,614	204,791	6,495	101,888	144	1,299	60,00
Massachusetts	305,415	1,573,478	75,860	918,700	6,000	95,000			75,00
Michigan	304,081	980,254	3,858	26,758			4,000	36,000	e 8,00
Minnesota	211,623	1,074,715	9,234	92,595	114	2,286			31,54
Mississippi	48,164	263,110	712	5,435			5,176	31,059	
Missouri	285,000	867,500	20,000	125,000	14,594	179,607	24,721	197,903	e 300,00
Montana	43,013	240,444	78	1,163	2,000	50,000	350	15,000	
Nebraska	108,512	643,227	3,810	30,476			5,714	40,524	
New Hampshire	63,484	335,273	6,490	67,850	1,180	23,600	944	8,496	
New Jersey	355,047	1,485,028	35,000	600,000	30,000	600,000	300	3,000	e 2,000,00
New Mexico	2,000	14,000	1,300	10,400	250	2,500			
New York	1,120,000	4,849,600	30,000	240,000	e 20,000	400,000	35,000	420,000	650,00
North Carolina	102,000	516,537	206	2,057	57	1,143	100	800	1,50
North Dakota	42,196	257,550	1,083	11,375	350	6,300	1,500	35,000	30
Ohio	522,949	3,089,783	66,359	129,896	105,779	2,114,582	e 200,000	1,800,000	e 375,00
Oklahoma	12,581	84,279							
Oregon	14,739	104,539	188	5,288	5	84			
Pennsylvania	797,681	5,246,237	61,998	663,946	100,774	1,606,213	68,887	589,881	e 500,00
Rhode Island (e)	40,000	210,000	1,500	13,500			5,000	45,000	15,00
South Carolina	142,837	652,781	904	9,047	e 600	6,000	500	2,500	
South Dakota	16,286	131,571	157	5,143			150	1,500	
Tennessee	126,768	650,963	3,048	30,479	48	481	e 12,000	170,000	e 2,00
Texas	141,340	838,032	5,799	63,143	500	7,500	2,767	24,800	
Utah	40,903	227,645	5,607	60,587					
Vermont	42,257	194,827	14,571	65,571					
Virginia	77,398	430,017	1,290	15,382			1,346	12,789	e 45,00
Washington	61,234	471,662	3,400	68,000			350	6,300	
West Virginia	23,012	116,417	1,750	21,000	e 400	4,800	e 25,000	220,000	e 5,00
Wisconsin	122,727	755,794	4,460	33,630					
Wyoming	e 300	2,700							
Totals	7,500,868	$39,195,913	455,771	$4,601,686	372,385	$5,823,268	724,370	$6,503,442	$5,530,369

its abandonment is of no serious consideration. The list of producers consequently is subject to continuous revision. A further difficulty arises from the fact that some concerns do not keep any records of their work, and are therefore not in position to furnish accurate reports.

The production of brick and clay building material by States in 1900 and 1901 is presented in the above tables, in which the columns "common brick" include only the ordinary red brick that is used generally in building. Under "front brick" we have grouped pressed brick of all colors. Under "fire brick," however, only what is properly termed alumina brick is included. Such silica brick as Dinas brick, which is also properly called "fire brick" or "refractory brick," being omitted, because it is not a clay product. "Other clay material" includes fancy or ornamental and enameled brick, roofing tile, terra cotta, terra cotta lumber, floor tile, hollow building blocks, etc. All the clay material other

CTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1901. (IN THOUSANDS.)

ates.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.	Paving Brick.	Sewer Pipe.	Other Clay Building Material.	Total Value.
	Quantity.	Value.	Quantity.	Value.	Value.	Value.	Value.	Value. (e)	
	Thous.		Thous.						
a.....	128,914	$742,691	795	$6,990	$132,783	(a)	.....	ƒ $1,800	$928,429
.....	13,533	92,986	.....	.....	.....	.....	.....	.....	92,986
as.....	56,501	368,359	1,205	11,570	13,580	(a)	.....	ƒ 950	395,858
ia.....	146,522	943,250	3,787	86,425	87,665	(a)	$285,599	ƒ 279,692	1,735,721
o	116,160	760,867	16,563	196,147	292,269	(a)	(a)	ƒ 170,965	1,568,167
icut and Island...	160,606	822,079	(a)	(a)	(a)	.....	.....	ƒ 109,500	1,089,709
e.....	15,963	126,092	(a)	(a)	.....	.....	.....	(f)	131,164	
Columbia	23,175	179,184	(a)	(a)	.....	.....	95,000	ƒ 134,652	311,129
.....	32,253	185,759	(a)	(a)	.....	.....	(a)	3,015	190,674
.....	222,111	1,182,553	5,325	55,700	35,000	(a)	151,500	ƒ 85,460	1,527,853
.....	8,391	66,514	(a)	(a)	.....	.....	.....	ƒ 272	68,328
.....	930,561	5,188,654	19,241	204,980	212,510	$899,454	348,716	ƒ 2,040,851	8,960,041
.....	315,966	1,624,133	27,293	234,775	51,526	320,221	253,626	1,400,402	3,935,083
erritory..	17,603	110,774	(a)	(a)	(a)	.....	.....	.....	117,224
.....	249,318	1,611,040	8,785	88,164	1,810	241,108	54,500	714,583	2,711,205
.....	108,365	555,928	5,495	50,340	(a)	312,994	(a)	ƒ 43,300	981,020
ty	115,977	621,756	2,486	16,535	377,741	(a)	100,705	ƒ 29,498	1,374,846
ia.....	94,981	560,375	(a)	(a)	.....	.....	.....	ƒ 27,220	612,595
.....	69,819	407,354	2,530	22,850	(a)	(a)	(a)	3,830	734,678
id.....	113,457	676,708	5,772	76,732	342,055	(a)	(a)	ƒ 82,811	1,272,175
usetts....	170,455	1,060,493	6,950	98,892	57,945	.....	.....	ƒ 211,911	1,589,469
n.....	215,836	1,095,254	9,476	64,031	.....	(a)	(a)	ƒ 101,489	1,497,169
ta.....	157,727	852,303	5,506	55,016	(a)	.....	(a)	ƒ 43,089	1,256,552
ppi.....	76,716	443,939	650	6,455	.....	.....	.....	(f)	451,694
i.....	276,821	1,595,031	26,301	298,158	620,116	225,247	788,513	818,701	4,469,906
a.....	51,739	357,210	1,248	18,432	152,650	.....	(a)	ƒ 2,539	539,221
na.....	109,060	668,863	6,806	85,260	.....	28,150	.....	11,700	806,473
.....	2,020	16,425	(a)	(a)	.....	.....	.....	.....	17,625
mpshire..	114,532	741,589	(a)	(a)	(a)	.....	.....	.....	765,964
sey.....	351,886	1,675,746	29,239	473,138	780,327	22,024	(a)	ƒ 2,510,092	5,781,805
xico.....	9,885	72,045	(a)	(a)	.....	(a)	.....	(f)	81,345
rk	1,016,237	4,947,599	18,721	254,696	293,944	343,343	96,770	ƒ 1,278,888	7,214,358
arolina...	132,699	682,469	990	8,070	3,720	(a)	(a)	ƒ 10,042	751,301
akota....	10,948	69,508	(a)	(a)	(a)	.....	.....	.....	76,708
.....	489,275	2,725,512	69,405	612,718	1,287,059	1,443,537	2,735,703	ƒ 2,709,601	11,526,424
na.....	28,137	156,735	875	7,850	(a)	.....	.....	(f)	205,060
(b).....	23,422	172,058	354	8,469	962	.....	(a)	ƒ 12,179	263,891
vania.....	875,631	5,357,079	70,207	844,087	4,791,083	670,081	438,998	1,490,315	13,656,730
arolina...	144,601	546,028	168	1,188	14,925	.....	.....	ƒ 250	563,346
akota....	7,235	54,365	(a)	(a)	(a)	.....	.....	.....	59,365
ee	92,502	610,968	3,073	32,350	37,100	67,129	(a)	ƒ 15,961	829,874
.....	222,459	1,396,889	10,138	95,492	23,337	(a)	(a)	ƒ 11,971	1,632,189
.....	23,202	134,164	17,490	139,591	5,100	.....	(a)	ƒ 1,834	291,189
t.....	11,872	61,554	.....	.....	.....	.....	.....	16,000	77,554
.....	171,624	1,139,894	17,650	267,028	3,971	.....	.....	24,407	1,435,300
gton.....	61,595	477,960	6,995	147,881	24,542	139,162	118,584	ƒ 3,343	927,296
irginia....	60,004	348,452	(a)	(a)	102,300	555,389	(a)	ƒ 3,985	1,087,838
sin	187,173	1,151,838	6,527	54,374	(a)	(a)	.....	ƒ 26,232	1,234,144
ng	2,960	24,050	(c)	(c)	.....	.....	.....	4,900	28,950
tates (d)..	.....	.....	7,297	85,788	124,401	216,295	1,268,755	641,561	(f)
.....	8,038,579	$45,503,076	415,343	4,709,737	9,870,421	$5,484,134	$6,736,969	$15,443,390	$87,747,727
t. of brick e products	.....	51·86	.....	5·37	11·25	6·25	7·68	.....	100·00
t. of total products.	.....	41·29	.....	4·27	8·96	4·98	6·11	.....	79·62

included in "Other States." (b) Includes Hawaii. (c) Value of front brick for Wyoming included in ay building material. (d) Includes all products made by less than three producers in one State, in order operations of individual establishments may not be disclosed. (e) Fancy and ornamental brick, stove drain tile, ornamental terra cotta, fireproofing, ordinary tile, including adobes, assayers' sup- ller and locomotive tile and tank blocks, building blocks, burnt clay ballast, chemical brick, patent brick, chimney pipe and tops, clay furnaces and retorts, conduit for underground wires, crucibles, brick, fence posts and stubs, fire clay mortar, flue linings, frost-proof cellar brick, furnace mantels, and settings, glass-melting pots and glass-house furnace blocks, grave markers, hollow bricks, muffles, s and slides, porous cups, runner brick, sidewalk tile, souvenirs, stone pumps, terra-cotta vases, vitri- er brick, wall coping, water pipe, and well brick and tile. (f) Partly included in "Other States."

brick, which is now used so extensively in the construction of fireproof ngs is included under this classification. A slightly different classification en adopted for 1901, which is fully explained in the individual headings columns and in *the appended foot notes.*

VALUE OF THE PRODUCTS OF CLAY IN THE UNITED STATES IN 1900 AND 1901.

State.	1900.			1901.		
	Brick and Tile.	Pottery.	Total.	Brick and Tile.	Pottery.	Total.
Alabama	$692,431	$30,296	$712,727	$928,429	$18,362	$946,791
Arizona	112,737	.....	112,737	92,986	.....	92,986
Arkansas	354,732	26,280	381,012	396,858	11,405	407,263
California	1,351,611	24,387	1,375,998	1,735,721	33,434	1,769,155
Colorado	1,182,575	*a* 17,944	1,200,519	1,568,167	26,700	1,594,867
Connecticut and Rhode Island	1,038,722	61,250	1,099,972	1,039,709	*k* 91,200	1,130,909
Delaware	156,274	.....	156,274	131,164	.....	131,164
District of Columbia	278,060	10,873	288,933	311,129	12,879	324,008
Florida	140,604	(*b*)	140,604	190,674	(*b*)	190,674
Georgia	1,168,835	*b* 24,383	1,193,218	1,527,853	17,230	1,545,083
Hawaii	.....	.....	.....	(*l*)	.....	(*l*)
Idaho	49,382	(*a*)	49,382	68,328	.....	68,328
Illinois	6,932,086	776,773	7,708,859	8,960,041	682,449	9,642,490
Indiana	3,532,450	*c* 325,900	3,858,350	3,985,083	581,371	4,466,454
Indian Territory	30,233	.....	30,233	117,224	.....	117,224
Iowa	2,254,662	36,589	2,291,251	2,711,305	26,520	2,737,825
Kansas	1,002,689	14,061	1,016,750	981,020	(*m*)	981,020
Kentucky	1,349,827	131,497	1,481,324	1,374,846	139,697	1,514,543
Louisiana	503,394	4,300	507,694	612,595	3,108	615,703
Maine	724,934	(*d*)	724,934	734,678	(*m*)	734,678
Maryland	1,275,239	436,617	1,711,856	1,272,175	333,480	1,605,655
Massachusetts	1,594,377	*d* 238,724	1,833,101	1,589,469	281,368	1,870,837
Michigan	1,147,378	34,317	1,181,695	1,497,169	44,865	1,542,034
Minnesota	1,103,302	*e* 293,395	1,396,697	1,256,552	292,095	1,548,647
Mississippi	558,916	14,452	573,368	451,694	4,779	456,473
Missouri	3,665,093	71,474	3,736,567	4,409,906	64,647	4,474,553
Montana	350,489	(*a*)	350,489	539,221	(*m*)	539,221
Nebraska	683,958	.....	683,958	806,473	.....	806,473
Nevada	9,580	.....	9,580	17,625	.....	17,625
New Hampshire	485,013	(*f*)	485,013	765,964	(*m*)	765,964
New Jersey	5,664,772	*f* 5,263,651	10,928,423	5,781,805	5,900,073	11,681,878
New Mexico	41,898	.....	41,898	81,345	.....	81,345
New York	6,495,281	*g* 1,165,325	7,660,606	7,214,358	1,077,360	8,291,718
North Carolina	797,112	18,863	815,975	751,301	20,037	771,338
North Dakota	92,399	.....	92,399	76,708	.....	76,708
Ohio	9,731,305	*h* 8,573,323	18,304,628	11,526,424	10,048,561	21,574,985
Oklahoma	164,457	.....	164,457	205,060	.....	205,060
Oregon	264,095	17,290	281,385	*n* 263,891	(*m*)	*n* 263,891
Pennsylvania	12,000,875	1,390,873	13,391,748	13,656,730	1,665,012	15,321,742
Rhode Island	(*i*)	.....	.....	(*i*)	.....	(*i*)
South Carolina	693,703	17,633	711,336	563,346	11,872	575,218
South Dakota	43,440	.....	43,440	59,365	.....	59,365
Tennessee	865,923	49,655	915,578	829,874	64,093	893,967
Texas	1,083,553	87,464	1,171,017	1,632,189	91,186	1,723,375
Utah	227,621	6,600	234,221	291,189	(*m*)	291,189
Vermont	121,041	.....	121,041	77,554	.....	77,554
Virginia	1,302,085	3,110	1,305,195	1,435,300	4,047	1,439,347
Washington	616,029	9,430	625,459	927,298	17,500	944,798
West Virginia	1,384,924	631,841	2,016,765	1,087,838	858,642	1,946,480
Wisconsin	1,072,179	(*e*)	1,072,179	1,234,144	13,400	1,247,544
Wyoming	21,500	.....	21,500	28,950	.....	28,950
Other States	.....	.....	.....	.....	*o* 76,488	*o* 76,488
Total	$76,413,775	$19,798,570	$96,212,345	$87,747,727	$22,463,860	$110,211,580
Per cent. of total	79·42	20·58	100·00	79·62	20·38	100·00

(*a*) Value of the pottery products of Idaho and Montana is included with that of Colorado. (*b*) Value of the pottery products of Florida is included with that of Georgia. (*c*) Porcelain electrical supplies for Indiana included in New York. (*d*) Value of the pottery products of Maine is included with that of Massachusetts. (*e*) Value of the pottery products of Wisconsin is included with that of Minnesota. (*f*) Value of pottery products of New Hampshire is included with that of New Jersey. (*g*) Includes porcelain electrical supplies for Indiana and china for Ohio. (*h*) China for Ohio included in New York. (*i*) Included with Connecticut. (*k*) Produced by Connecticut alone. (*l*) Included in Oregon. (*m*) Included in "Other States." (*n*) Includes Hawaii. (*o*) Comprising pottery totals for the following States: Florida, Kansas, Maine, Montana, New Hampshire, Oregon and Utah. This total could not be distributed among the States to which it belongs without disclosing the operations of individual establishments.

As an exponent of the increasing use of burned clay products as a building material may be cited the number of building permits issued, together with the buildings erected under these permits in 42 of the principal cities of the United States for the past two years. In 1900 there were 68,417 permits affecting buildings valued at $241,516,585, as compared with 85,571 permits affecting buildings valued at $372,173,631 in 1901, an increase in number of 25% and of over 50% in value.

[illegible] Literature of Clays and Clay Products in 1902.

By Heinrich Ries.

[illegible] - Salem pot clays have been obtained in the United States from [illegible] are to a small extent in Pennsylvania, and have partially replaced [illegible] pot clays. Their chemical composition and physical properties [illegible] properties of foreign clays have been described by [illegible]

[illegible] The manufacture of brick from both shale and clay has attained [illegible] importance in the vicinity of Boulder.[1]

[illegible] The [illegible] known St. Louis glass pot clays have been made the subject [illegible] physical and chemical study by O. Muehlhauser.[2]

[illegible] A recent development of kaolin near Bryson City, Swayne [illegible] by [illegible] Crane.[3] The composition of the kaolin is as follows: [illegible] Al_2O_3, 35.87%; Fe_2O_3, 1.22%; CaO, 1.25%; MgO, 0.79%; [illegible] 1.22%; combined H_2O, 10.05%.

[illegible] These waters are [illegible] several localities in this State.[4] They [illegible] the manufacture of brick, drain tile, sewer pipe, terra cotta, etc. [illegible] types recognized are glacial clays, residual clays and clay shales. [illegible] first mentioned are irregular in their occurrence, while the second [illegible] in well-[illegible] areas.

[illegible] Shales are found in Carboniferous rocks near Pilsen, Bohemia, [illegible] by [illegible] Pochmon,[5] have resulted from the decomposition of an [illegible] a complete chemical composition is: SiO_2, 57.02%; Al_2O_3, 24.37%; [illegible] 2.76%; MgO, 0.19%; alkalies, 0.62%; loss on ignition, [illegible]

[illegible] near Salt [illegible] SiO_2, 50.22%, [illegible] MgO, 1.12%; loss on [illegible]

[illegible] Brown [illegible] including the [illegible] and fusion.[6]

[illegible] Hankinson[7] describe the occurrence of beds of [illegible] at Neuruppin, near Berlin.[8] Two varieties [illegible] [illegible] from analyses: SiO_2, 52.12%; Fe_2O_3, [illegible] 1.12%; CaO, 0.22%; MgO, 0.22%; alkalies [illegible]

[illegible]

[illegible]

poor transportation facilities, the market is very limited, and at most localities pottery is made only in a small way for local or domestic use. The region around Nizhni Novgorod is an important one. In some districts lack of clay and fuel gives serious trouble.

PROPERTIES OF CLAYS.—*Softening Temperature.*—E. Cramer[12] discusses his method of testing the softening temperature of fire clays by making small bars and noting the temperature at which these bend when supported at two points. He finds that the clays which burn to a dense body at comparatively low temperatures are not necessarily those which soften first; that, in fact, porous kaolins may soften at an earlier point than the dense-burning clays. Experiments to determine the effect of adding finely powdered sand to the bars showed that it did not affect all clays alike, tending to soften some and to stiffen others when burned to the same temperature.

Dehydration.—In experiments to determine the temperature of dehydration of calcareous clays and kaolin, W. M. Kennedy[13] finds that the water of hydration of the kaolin passes off between 450° and 600°C., and in a mixture of 70 parts of Florida kaolin and 30 parts of whiting he found that the loss which occurred between the two temperature points above mentioned agreed with kaolin, and represented the period of dehydration. On further heating from 600° to 725°C. the expulsion of volatile matter was almost as rapid as that of the water. Another rapid loss occurred between 850° and 900°C. Holding the clay at a temperature of 725°C. did not seem to hasten the dehydration.

Plasticity.—A rather unique explanation of this peculiar property is given by E. Linder.[14] He explains it partly by supposing that the particles are of extreme fineness, and further considers that weathering produces very long or round particles, the former giving greater contact surface, and thereby increasing the surface tension and the plasticity. He believes that if clays have rounded particles they will burn dense only at high temperatures, while in those clays whose particles are elongated the reverse occurs.

Permeability.—An interesting series of experiments has been made by W. Spring,[15] who finds that clay when under pressure and confined so that it cannot expand on wetting is nearly impervious to water; under such conditions it will only soak up enough water to fill the pores. The percentage of water thus absorbed may range from as low as 3·37% in glass-pot clays, to 24·56% in some loams. Wet clay under pressure will part with its water, even though the mass be entirely surrounded by that liquid.

Composition.—Mackler[16] discovered that the presence of magnesia in clays results in the formation of a dense body at a relatively low kiln temperature, and that this material exerts quite a different effect from that exerted by lime. He found that clays containing magnesia do not vitrify and shrink so suddenly as do the calcareous clays, nor does the magnesia exert as strong a bleaching action on the iron of the bricks as the lime does. The effect of adding magnesia

[12] *Thonindustrie Zeitung*, Vol. XXVI., p. 1067.
[13] *Transactions of the American Ceramic Society*, Vol. IV., p. 146.
[14] *Thonindustrie Zeitung*, Vol. XXXVI., p. 382.
[15] *Annales de la Société géologique de Belgique*, Vol. XXVIII., 1901.
[16] *Thonindustrie Zeitung*, Vol. XXVI., p. 705.

[illegible] the material to burn denser at cone No. 1, whereas others [illegible] the same density until cone No. 16. He suggests the [illegible] magnesia in pottery bodies as a substitute for lime or feld-

[illegible] Kanaiwoshi[illegible] describes an apparatus for the mechanical [illegible] of a pear-shaped receptacle with a wide mouth and [illegible] openings. The first opening is for the outlet of air, while [illegible] the second is for the water inlet tube, and the third [illegible] The latter can be moved up and down so that its [illegible] at any level in the receptacle. The disintegrated sample to [illegible] water are placed in the bottom of the receptacle with the [illegible] tube raised to near the top. Water is then allowed to [illegible] through the outlet tube until it becomes clear. The outlet [illegible] further into the receptacle so that its lower end is about [illegible] the zone in which the fine sand particles remain suspended [illegible] the water through the tube, and these are then drained [illegible] tube is pushed still farther into the receptacle and the [illegible] it. To separate the coarser sizes of sand the residue is [illegible] egg-shaped cone, outside of which are two other cones. The [illegible] are [illegible] mm., those of the next cone 1 sq mm., and [illegible] mm. These cones are then suspended by a string in the [illegible] water, and the grains of sand are washed toward the outer [illegible] are caught while the coarsest grains are retained in the [illegible]

[illegible] Koshiki[illegible] gives the methods for the rational analysis [illegible]

obtained with strongly alkaline glazes when lead is excluded. He also describes the effect of the addition of whiting to clear alkaline glaze and the production of crimson with the combination of tin oxide, lime and chrome. The occurrence of a golden yellow sheen on lead glazes, due to the formation of small lustrous yellow crystals, is believed by L. Thiriot[23] to be traceable to the high proportion of lead oxide to silica in the glaze (about 1 : 1), when quartz sand is used. A low temperature and gradual cooling also aids the formation of these crystals. A solid-colored glaze consisting of crude or burned pyrite, to which is added some clay, sand, ground glass and other substances, is used in many parts of Germany[24] for interlocking and shingle tiles. The air-dried ware is dipped in the glaze and then set in the kiln. According to M. Heim[25] the tendency of some stoneware glazes to deposit sediment can sometimes be remedied by the addition of crude plastic clay and kaolin, white lead, or chalk to the mass before it received its final grinding. It may also be prevented by increasing the density of the liquid portion of the glaze with gum, dextrin, syrup, milk, blood, borax, boric acid, or acetic acid. The sediment, however, hardens sometimes, and can only be redistributed by regrinding, but successive treatment of this kind works injury to the glaze. W. P. Rix[26] describes the conditions necessary to successful glazing, stating that the temperature must not be lower than 1,200°C., and that the body material should be highly siliceous. L. E. Barringer[27] also takes up the question of the relation between the constitution of the clay and its ability to take a good salt glaze, and finds that clays with a wide molecular ratio of alumina to silica, *viz.*: from 1 : 4·6 to 1 : 2·5 can be treated in this manner. He also states that soluble salts up to 3% may be present in a clay without seriously interfering with salt glazing when conducted at cone No. 8. S. Geisjbeek[28] claims that he was not able to find any good natural engobe clays in the United States, but that a good engobe could be made by adding flint and spar to some of our domestic clays.

Bodies.—Mica, when ground exceedingly fine, is found by R. L. Stull[29] to exert a fluxing action upon kaolin at temperatures below cone No. 5. He claims also that it is plastic if ground fine enough, and that it vitrifies sufficiently to produce a non-absorbent body below the temperature of cone No. 4.

PORCELAIN.—A. S. Watts[30] is of the opinion that every porcelain showing a high resistance test contains moderately large quantities of Al_2O_3 and SiO_2 but not over 1% Al_2O_3 and 6·2% SiO_2 should be used. He found that no specimens below 0·8% Al_2O_3 and 4·2% SiO_2 were safe, owing to their very narrow vitrification limits. He believes that the ideal porcelain for electrical purpose may be vitrified at any point between Nos. 6 and 12.

E. Mayer[31] points out the need of finer grinding of the American potter materials, and finds that the English ground flint is considerably finer than the American ground flint. H. E. Wood[32] states that the employment of bon

[23] *Sprechsaal*, 35 [32], 1210-11.
[24] *Ceramische Rundschau*, 1902. [25] *Sprechsaal*, Vol. XXXV., p. 1337.
[26] *Transactions of North Staffordshire Ceramic Society*, Vol. I., p. 26, 1901-02.
[27] *Transactions of the American Ceramic Society*, Vol. IV., p. 211.
[28] *Ibid.*, Vol. IV., p. 48. [29] *Ibid.*, Vol. IV., p. 255. [30] *Ibid.*, Vol. IV., p. 86. [31] *Ibid.*, Vol. IV., p. 25.
[32] *Transactions of North Staffordshire Ceramic Society*, Vol. I., 1901-02, p. 21.

[illegible] dates from the middle of the eighteenth century. The author [illegible] that the lime remains as calcium phosphate throughout the firing, and [illegible] as the silicate without affecting their translucency, but that it increases the [illegible] and lightness of the body, and furthermore that being [illegible] to [illegible] it is a safeguard against overfiring, and hence [illegible] softening, as well as crazing.

[illegible] H. Kerr[1] considers the use of enameled tiles for saving or repairing [illegible] and [illegible] decoration. He reviews also the history of their use in [illegible]

[illegible] Kerr[2] considers that face brick should not absorb more than 5% [illegible] that a transverse test is applicable in cases where brick are laid [illegible] from the wall and are to support loads. Bricks with lime pebbles [illegible] and the same is true of bricks containing pyrite nodules. A [illegible] available for proof to the action of the weather, and sulphates [illegible] the clay should be rendered harmless by the action of barium. [illegible] should be burned especially hard in order to prevent the formation [illegible] due to vanadium. The destruction of brickwork has [illegible] in several places in Italy, and, according to Capri[3] is due to [illegible] of recrystallization of alkaline sulphates in some instances, and mag[illegible] in others. In some cases a portion of the alkaline compounds [illegible] to alkaline sulphides in the clay, and a further quantity to the [illegible] used for fixing the lime. As a result, it is suggested [illegible] be possible to set a maximum limit for the presence of such [illegible]. Two tests were suggested: (1) Determination of sulphur [illegible] (2) [illegible] by heating.

[illegible]

[illegible]

[illegible]

[illegible]

COAL AND COKE.

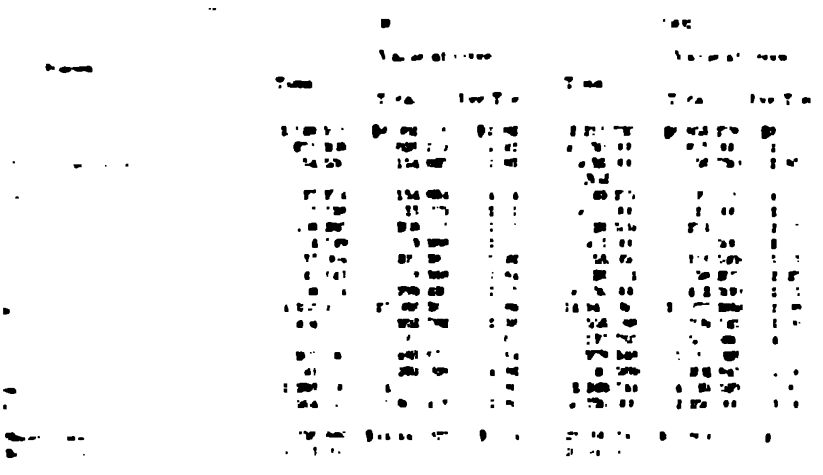
THE continued industrial prosperity of the United States during 1902 caused the production of coal to exceed the enormous total registered in 1901. The total production of anthracite and bituminous coal amounted to 299,823,254 short tons, as compared with 293,298,516 short tons in 1901. Had it not been for the protracted strike in the anthracite region of Pennsylvania, the production in 1902 would have attained to still larger proportions. The total production of coal in the chief countries of the world during 1901 was 787,179,967 metric tons, against 766,935,262 metric tons in 1900.

TOTAL PRODUCTION OF COAL IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1901.			1902.		
	Tons.	Value at Mine.		Tons.	Value at Mine.	
		Total.	Per Ton.		Total.	Per Ton.
Bituminous:						
Alabama	9,099,052	$10,000,892	$1·10	10,329,479	$12,498,669	$1·21
Arkansas	1,816,136	2,068,613	1·14	2,195,700	2,338,270	1·10
California	151,079	394,106	2·61	88,460	248,622	2·81
Colorado (e)	5,635,435	6,248,151	1·11	7,455,156	8,349,768	1·12
Georgia	354,825	426,685	1·20	e 375,000	450,000	1·20
Illinois	27,331,552	28,163,937	1·03	30,031,300	28,289,485	0·94
Indiana	6,918,225	7,016,143	1·01	8,300,000	7,885,000	0·95
Indian Territory	2,421,781	3,915,268	1·62	2,741,797	4,386,875	1·60
Iowa	5,617,499	7,822,605	1·39	5,407,144	7,908,004	1·46
Kansas	4,900,528	5,991,599	1·22	5,229,767	7,321,674	1·40
Kentucky	5,469,986	5,213,076	0·95	6,429,419	6,107,948	0·95
Maryland	5,113,127	5,046,491	0·99	5,525,785	6,225,639	1·13
Michigan	1,241,241	1,753,064	1·24	869,228	1,173,458	1·35
Missouri	3,802,088	4,707,164	1·24	4,067,166	5,324,788	1·31
Montana	1,396,081	2,009,316	1·44	1,707,109	2,389,953	1·40
New Mexico (d)	1,084,257	1,540,357	1·42	1,090,373	1,537,426	1·41
North Dakota (b)	166,601	214,151	1·29	296,800	371,000	1·25
Ohio	20,943,807	20,928,158	1·00	23,929,267	24,843,608	1·08
Oregon	69,011	173,646	2·52	e 60,000	150,000	2·50
Pennsylvania	82,305,946	81,397,586	0·99	98,946,203	106,861,899	1·08
Tennessee	3,633,290	4,067,389	1·12	4,232,332	5,278,921	1·25
Texas (c)	1,107,953	1,907,024	1·72	e 850,000	1,360,000	1·60
Utah	1,322,614	1,666,082	1·26	1,641,436	2,068,209	1·26
Virginia	2,725,873	2,353,989	0·96	3,070,104	3,223,609	1·05
Washington (d)	2,578,217	4,271,076	1·66	2,690,789	5,300,854	1·97
West Virginia	24,068,402	20,848,184	0·87	26,162,173	27,208,660	1·04
Wyoming	4,485,374	6,060,462	1·33	4,720,000	6,472,000	1·35
Total bituminous (Sh. tons)	225,759,980	$236,305,214	$1·05	258,371,987	$285,574,339	1·11
Total bituminous (Met. tons)	204,808,110	.....	1·15	234,393 529	.....	1·22
Cannel: Kentucky (Sh. tons)	(g)	.....	.....	(g)	.....	.....
Cannel: Kentucky (Met. tons)	(g)	.....	.....	(g)	.....	.....
Anthracite:						
Colorado	64,580	$193,740	$3·00	67,767	$203,301	$3·00
New Mexico	2,289	6,295	2·75	42,571	117,070	2·75
Pennsylvania	67,471,667	112,504,020	1·67	41,340,929	82,681,858	(f) 2·00
Total anthracite (Sh. tons)	67,538,536	$112,704,055	$1·67	41,451,267	$83,002,229	$2·00
Total anthracite (Met. tons)	61,270,558	.....	1·84	37,604,343	.....	2·20
Grand total coal (Sh. tons)	293,298,516	$349,009,269	$1·19	299,823,254	$368,576,568	1·23
Grand total coal (Met. tons)	266,078,668	.....	1·31	271,997,872	.....	1·35

(a) Fiscal year. (b) All lignite. (c) One-third lignite. (d) One-half lignite. (e) Estimated. (f) Estimated; owing to the protracted strike in the Pennsylvania anthracite region and the abnormal conditions which resulted in the trade, the value of anthracite at the mine can be fixed only approximately. (g) Included in bituminous.

Ohio.—The production of coal showed an increase of about 14% in 1902, the figures being 23,929,267 against 20,943,807 in 1901. The large increase was due primarily to the strong demand for coal resulting from the decreased *supply furnished by* Pennsylvania.



PRODUCTION AND CONSUMPTION OF COAL IN THE UNITED STATES. (IN LONG TONS.)

Year.	Production.	Imports.	Total Supply.	Exports.		Consumption.	
				Domestic.	Foreign.	Tons.	Metric Tons.
1898.....	194,940,967	1,273,706	196,214,673	4,503,405	2,890	191,708,378	194,775,712
1899.....	225,103,024	1,400,522	226,503,546	5,752,150	6,806	220,744,590	224,276,508
1900.....	239,567,351	1,909,376	241,476,727	7,917,519	6,740	233,552,468	237,289,307
1901.....	261,878,675	1,920,248	263,798,923	7,383,393	3,808	256,406,727	260,509,235
1902.....	267,609,334	2,551,381	270,250,715	6,126,946	7,581	264,116,188	268,342,047

Exports and Imports.—There was a decrease in the exports of coal during 1902, the figures being 6,126,946 tons for 1902, as compared with 7,383,393 tons in 1901. The imports increased from 1,920,248 tons in 1901, to 2,551,381 tons in 1902. Both imports and exports are given in the subjoined table:—

UNITED STATES EXPORTS AND IMPORTS OF COAL CLASSIFIED AS TO COUNTRIES.

Country.	Exports.			Imports. (a)		
	1900.	1901.	1902.	1900.	1901.	1902.
Australasia	*Nil.*	*Nil.*	*Nil.*	254,183	351,105	334,563
Canada	5,422,493	5,080,963	4,468,593	1,484,576	1,438,531	1,678,919
Central and South America	223,795	291,816	181,004	.....	.....	.....
Europe	635,237	589,576	186,695	118,987	77,389	456,998
Hawaii and Philippine Islands	96,870	71,718	67,673	*Nil.*	*Nil.*	*Nil.*
Japan	*Nil.*	*Nil.*	*Nil.*	9,045	11,068	9,556
Mexico	664,086	551,448	537,708	41,326	19,702	8,087
West Indies	760,859	735,380	679,988	*Nil.*	*Nil.*	*Nil.*
Others	114,209	62,483	5,285	1,141	22,317	392
Totals	7,917,519	7,383,393	6,126,946	1,909,258	1,919,962	2,478,375

(a) Does not include anthracite coal.

PRODUCTION OF COAL IN THE CHIEF COUNTRIES OF THE WORLD.

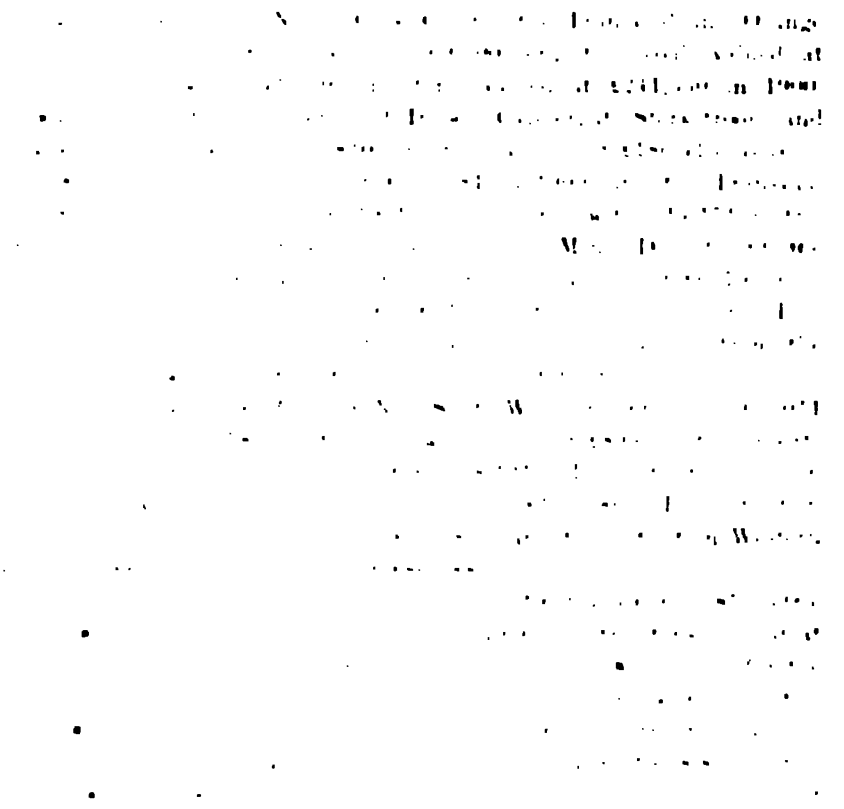
The total production of coal in the world during 1901 was 787,179,967 metric tons, against 766,935,262 metric tons in 1900, an increase of 40,385,224 metric tons during the year. Detailed statistics may be found in the subjoined table:—

COAL PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

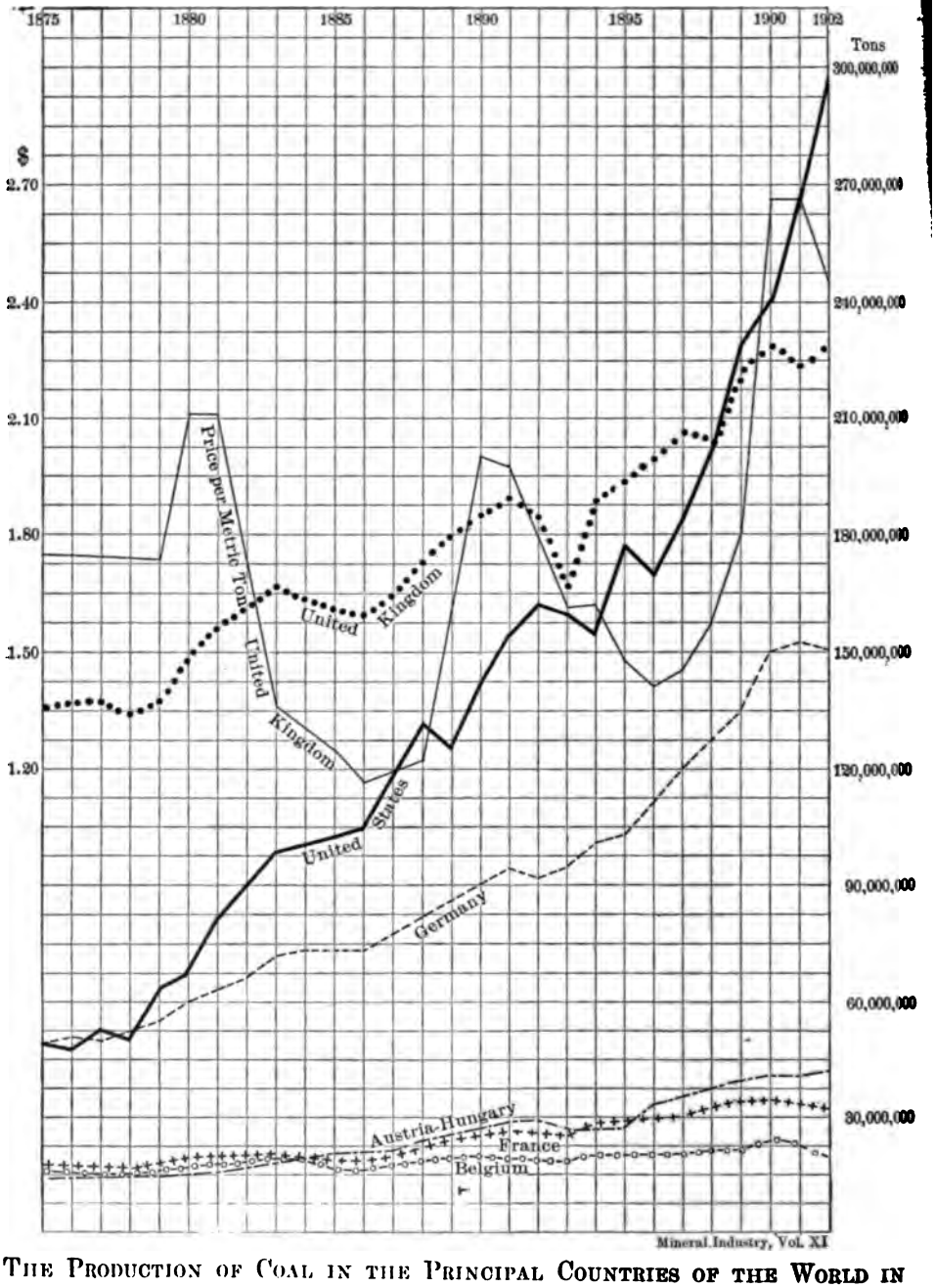
Year.	Africa.	Australasia.						Austria-Hungary	Belgium.	Canada.		France.
		New South Wales.	New Zealand.	Queensland.	Tasmania	Victoria.	Western Australia			British Colu'bia & Territories	N. Brunsw'k. Nova Scotia.	
1897	2,003,174	4,453,728	854,164	364,142	43,210	240,003	*Nil.*	35,939,416	21,492,446	1,167,153	2,267,581	30,798,000
1898	(a)2,550,485	4,781,551	921,546	414,461	49,002	246,845	330	37,786,962	22,068,336	1,454,452	2,330,890	32,356,107
1899	a 289,443	1,670,580	990,838	501,913	43,803	266,578	55,208	38,738,372	22,072,068	1,601,633	2,866,144	32,862,713
1900	759,362	5,595,879	1,111,890	505,252	51,549	215,052	120,305	39,027,929	23,462,817	1,791,696	3,296,322	33,404,296
1901	1,388,295	6,063,921	1,247,280	547,624	46,165	212,678	119,721	40,746,704	22,213,410	1,861,948	3,798,168	32,335,302

Yr.	Germany.	India.	Italy.	Japan.	Russia.	Spain. (f)	Sweden	United Kingdom.	United States.	All Other Countries	Totals.
1897	120,474,485	1,128,137	314,222	5,647,751	11,203,738	2,019,000	224,343	205,364,010	182,216,466	e2,000,000	633,215,229
1898	127,958,550	1,078,610	341,327	6,051,208	12,307,450	2,166,800	236,277	205,287,388	198,071,199	e2,500,000	665,480,716
1899	135,844,419	5,016,055	388,534	6,721,798	14,274,361	2,000,279	239,344	223,616,279	228,717,579	e2,500,000	724,828,145
1900	149,788,256	6,216,822	479,890	7,129,457	14,759,806	2,582,972	252,320	228,772,880	243,414,164	e2,500,000	766,935,262
1901	152,628,931	6,742,176	425,614	8,945,939	16,156,088	2,651,857	271,509	222,614,981	266,078,088	e2,500,000	787,179,967

(a) Includes estimate of 50,000 tons as the output of the Orange Free State and Transvaal, for which no statistics are available. (e) Estimated. (f) Not including lignite.



Europe.—The production of coal in the United Kingdom during 1902 amounted to 227,178,140 long tons, as compared with 219,037,240 long tons in 1901, an increase of 8,140,900 long tons during the year, the greatest individual



THE PRODUCTION OF COAL IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.

long tons. The coal exported in 1902 amounted to 43,160,113 long tons, 41,[illegible] long tons in 1901, an increase of 1,[illegible],002 long tons. The output in Prussia in 1902 was 90,190,[illegible] metric tons, as compared with [illegible] tons in 1901, the decrease being due to the strike of miners at the beginning of the year. Of this total the Saarbrücken coal fields contributed [illegible] tons, while nearly the whole of the lignite was obtained from the districts of Bonn and the Saar. The output of coal in the German Empire and Luxemburg in 1902 was 107,[illegible],111 metric tons bituminous and 44,[illegible],476 metric tons coal, a total of 150,[illegible],587, as compared with 108,539,444 metric tons coal and 46,[illegible],070 metric tons brown coal, a total of [illegible] tons in 1901. The exports of coal, including lignite, during 1902 were [illegible] metric tons, as compared with 15,[illegible],981 metric tons in 1901. The exports of the same products were 11,[illegible],468 metric tons in 1902, as against [illegible] 331 metric tons in 1901. The exports of coke in 1902 were [illegible] tons, as compared with 2,[illegible],941 tons in 1901, and the imports were [illegible] tons as compared with [illegible],197 tons in 1901. In Southern Russia for the year ending Aug. 31, 1902, the output of bituminous coal was [illegible] tons, as compared with 11,774,222 tons in 1901, the exports [illegible] tons for the same period in 1902, as compared with 2,065,845

The output of coal for the year 1902 was 6,[illegible],210 long tons, as compared with [illegible] long tons in 1901, the great bulk of which was produced in [illegible] 142,491 persons engaged in mining, 85,361, or [illegible]% were employed [illegible]. The best coal known as the Gondwana coal, is found [illegible] in Bengal, Central [illegible] Hyderabad [illegible] Rajputana, State in the [illegible] coal fields [illegible] the coal seams [illegible] The imports in 1901 were valued at $[illegible] as compared with [illegible] The exports in 1901 were valued at $[illegible] as compared with [illegible] The output of coal during 1901 from the ports of [illegible] was [illegible] tons, of which [illegible] tons were contributed by [illegible] In 1901 there were [illegible] collieries in operation, of which [illegible] were in the province of Kiangsu, [illegible] in Hupeh, [illegible] in Chihli, [illegible] in Honan, [illegible] in Shantung, [illegible] in Shensi, [illegible] in Kiangsi, [illegible] in Kwangtung, [illegible] in Kwangsi, [illegible] in Yunnan, [illegible] in Szechuen, [illegible] in Kweichow, [illegible] in Fukien, [illegible] in Chekiang, [illegible] in Anhwei, [illegible] in Shansi, [illegible] in Kansuh, [illegible] in Manchuria, [illegible] in Mongolia, [illegible] in Formosa, [illegible] in Hainan

and to put in new coke ovens, and it is expected the coke output will be increased to 500 tons daily. The company, which owns 30,000 acres of coal, has 2,000 men on its pay-roll. Its nearness to Monterey gives the company a market for its coal. The San Marcial coal mines, in the State of Sonora, are being developed so as to produce 150 to 200 tons of coal per diem. A railway is being constructed from the Sonora Railway to the mines, and it is proposed to ship coal to the interior in the summer of 1903.

South America.—The imports of coal into Chile are shown in the following table, reported in long tons, for which we are indebted to the courtesy of Jackson Bros., of Valparaiso:—

Year.	Steam Coal.						Smelting Coal.		
	Hartly.	Orrell.	Other Classes.	Australian.	North American.	Total.	English.	Australian.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898	134,177	8,591	100,480	270,087	10,608	523,941	8,599	42,763	51,362
1899	125,042	7,633	151,325	307,119	3,200	594,319	24,073	43,277	67,350
1900	88,655	10,341	121,284	356,859	35,000	612,739	15,657	46,350	62,007
1901	110,280	6,804	217,080	442,380	33,150	809,644	25,868	55,099	80,967
1902	122,965	5,876	255,883	345,154	34,887	764,765	10,570	54,273	64,843

THE ANTHRACITE COAL TRADE IN 1902.

BY SAMUEL SANFORD.

THE year 1902 will always be known as the year of the great strike, which greatly curtailed shipments for about five months, caused a loss of fully $26,000,000 in gross earnings to railroad companies and of $25,000,000 in wages to mine employees, and gave rise to much inconvenience and even distress. From its start in May, the strike was the controlling factor in the trade.

There were few important transfers of coal properties during the year, and there were no material changes in the general policies of the coal carrying railroads. The Delaware & Hudson Co. turned over to the Erie Railroad its tidewater shipments on a sales contract and also transferred to that road its business at Buffalo. The resignation of President Walter of the Lehigh Railroad, owing to dissatisfactions on the part of certain stockholders with his policy of putting the road's earnings into substantial improvements, was an outcome of the strike. In March, Geo. A. Holden retired as general sales agent of the Delaware, Lackawanna & Western; his retirement marking the final reorganization of the road under Mr. Truesdale, and the end of the long Sloan and Holden regime. The most important event of the year was not made known till the spring of 1903. The banking house of Kuhn, Loeb & Co. purchased in open market almost a controlling interest in the Reading Co. The stocks bought were first and second preferred and common, the largest purchases, relative to the total issue of each class, being in second preferred. It is not known just why Kuhn, Loeb & Co. made the purchases. Possibly the object was to prevent the Wabash Railroad from getting control of the Reading and thus making trouble for the Pennsylvania Railroad. Possibly J. P. Morgan, thinking his control of the

[illegible] did not think that any outside interest [illegible] was willing to sell his holdings at a [illegible] Kuhn, Loeb & Co bought the stock, and the [illegible] afterward transferred part to the Baltimore & Ohio Railroad and to the Lake Shore. By acquiring its large interest in Reading [illegible] took a leading position among the anthracite railroads. The [illegible] disposal of nearly all the Reading stock

[illegible] Market. At the close of December of the preceding year had [illegible] the demand at the opening of 1902 was strong. The [illegible] New York Harbor shipping ports were: Broken $4, egg [illegible] at $4 for white the steam sizes were in demand at $3 [illegible] and $2 for rice. Cold weather during much of [illegible] consumption but by March 1, the prospect of lower prices [illegible] March 1 however, disastrous floods the worst in 10 years, [illegible] suspension of shipments from the Lackawanna. Wyo- [illegible] Susquehanna River rising 32 ft [illegible] damage was done to the tracks of the Central Railroad [illegible] the Lehigh Valley along the Lehigh River, while in the [illegible] regions many collieries were flooded some of which [illegible] The total damage to railroads and mines [illegible] On April 1, the principal companies [illegible] New York Harbor shipping port, prices for April [illegible] and egg stove and chestnut $4. Egg was then put on a [illegible] and the differential on broken was reduced to 5c. in accord [illegible] for April were [illegible] May 1 [illegible] would continue well into the summer [illegible]

were busy. At Lake Superior ports most docks were bare, and at Missouri and Mississippi River points dealers were trying to get Colorado anthracite and Arkansas semi-anthracite. Prices in Eastern cities showed wide variation according to the supplies available, though egg and broken were practically out of the market, the Manhattan Elevated Railroad taking all of these sizes it could get, even at points as far away as Albany and Boston. Speculative coal bought up by jobbers, was offered wholesale alongside New York Harbor at these prices: Stove $8·45, chestnut $8·35, pea $7, buckwheat $4·40, rice, $3. Supplies continued to get scarcer, and prices rose. By September 10, prepared sizes at Chicago sold for $11 and $12 at retail and $10 and $11 at wholesale, with visible supplies down to 15,000 tons. Retailers at New York were restricting deliveries to one ton or less, and getting $12 and $13 a ton. At Boston the retail price was $10. Baltimore and some other points along the seaboard, as well as Lake Superior ports, were out of anthracite.

Prices continue to advance, and by the opening of October, that section of the country north of Virginia was experiencing the worst shortage in anthracite since that coal came into general use, as shown by these retail prices: St. Paul $12, Kansas City $12, Saginaw, Mich., $12, Chicago $15 @ $16, Springfield, Mass., $16, Boston $20, Providence $20, New York $18 @ $25, with some sales as high as $27, Philadelphia $15 @ $20, Richmond, Va., $10. At New York, steam coal often of poor quality sold for: Pea $10, buckwheat $8, rice $6. By the middle of October the strike was virtually over, prices had fallen, and sales agents were overwhelmed with orders. The Philadelphia & Reading Coal & Iron Co. announced on October 5 that to cover the expenses due to the strike its regular winter prices would be advanced 50c. per ton on January 1, making its f. o. b. New York Harbor quotations: Broken $4·75, egg, stove and chestnut $5. Other companies followed the Reading. Fortunately, the weather during October and November was very mild, and with actual consumption under normal, the public did not suffer, though demand was far in excess of supply and speculative coal sold at a premium. By November 20, prices f. o. b. Chicago were: Broken $6·25, egg, stove and chestnut $6·50. In the East retail prices at Philadelphia had fallen to $7 and $9, and at Boston and Narragansett Bay ports to $9. At New York Harbor, where the nominal retail price was $6·50 speculative coal sold as high as $10 for prompt delivery. Some lots of very poor washery coal, steam sizes, sold at discounts.

Early in December, a cold wave with lower temperatures than for a corresponding date in thirty years stimulated demand and hindered coastwise shipments. Retail prices at New York rose to $7·50 and at Boston to $12, and remained there to the end of the year. It is important to note that during the strike some of the railroad coal companies managed to get a little coal for certain concerns which had to burn anthracite and this coal was sold at the regular list price, though prices in the open market were twice as high. The difference between list and speculative prices after the strike was marked, and it is almost impossible to say what were average selling prices at tidewater during the last half of the year.

[illegible] Bituminous Coal Trade in 1902

By Sam D. Sanders

Pocahontas and New River miners were preparing to go out, and the market soon became speculative. The output fell off about 80% when the Virginia and West Virginia miners stopped work on June 7. By June 25, speculative prices rose to $4·85 for the better grades of Clearfield f. o. b. New York Harbor. When the men began to return to work in July and transportation and car supply were fairly adequate, speculative prices dropped to $3·25, and there was complaint of an apparent connection between speculative prices and variations in car supply and transportation. By the middle of August, some Pittsburg coal was arriving at tidewater, and a few large blocks of Nova Scotia coals had been taken for delivery at points east of Cape Cod. At New York Harbor prices for Clearfield fell to less than $3 per ton. By the end of the month, the strike in the Pocahontas district and at most of the New River mines shipping to tidewater, was practically over, but car supply became poorer and transportation slower and Clearfield grades advanced to $3·55 f. o. b. New York Harbor. Then a serious car shortage began to develop, the market became suddenly nervous and speculative prices jumped, the Pennsylvania Railroad getting the blame. Bituminous coal supplanted anthracite in hotels and public buildings, and to some extent for domestic purposes; the New York, New Haven & Hartford Railroad unable to get coal on its contract with the Davis Coal & Coke Co., because of the dispute between the Pennsylvania and Wabash roads, was buying in the open market; yet car supply on the Pennsylvania fell off, transportation was poor and less than a normal tonnage of bituminous coal was arriving at shipping ports. Prices by September 25, were $6·35 at New York Harbor and as high as $8·50 f. o. b. at points beyond Cape Cod. Early in October, in some cases as high as $9 per ton was paid for Clearfield grades f. o. b. New York Harbor ports, the railroads were seizing coal in transmit, and many manufacturing concerns were closing down. In the East the situation had been relieved by imports of Canadian coal and purchases of Scotch, English and Welsh coals. By October 5, however, the anthracite strike was virtually over, and the market much quieter, Clearfield grades selling (in a few days) from $8 to below $6 at New York Harbor, and falling later to $4. Some English and Scotch coal was arriving at North Atlantic ports, some of it being offered at below $7 per ton f. o. b. New York. During October, car supply continued poor and transportation irregular with demand strong and prices rose to $6·25 by November 30, but with improved car supply dropped to $5·50 f. o. b. New York Harbor for Clearfield. Then car supply fell to 35% of the demand, cold weather and storms increased buying and interrupted coastwise shipments. In December, speculative prices jumped to $7·25 per ton f. o. b. New York Harbor and $10 at points beyond Cape Cod; while at Philadelphia before the end of the month, bituminous coal was selling for $7, or for more than the price of prepared sizes of anthracite.

[illegible]

temporary exceptions, there has never been any profit in the mining of anthracite. It is shown in the history of the trade, and it is needless to multiply the proofs of it. Millions have been made from the royalties on coal by fortunate landowners, both individuals and companies. Fortunes have been amassed in the transportation and in the marketing of coal, and immense sums have been realized in salaries, commissions, and in various other ways connected with and dependent on the producing of coal. But it must be admitted that in the actual business of mining coal and selling it at the colliery, there has rarely been any profit over a series of years. The country at large has been the chief beneficiary of the anthracite fields of Pennsylvania. No other industry in all this broad land, nor in all the world, has ever created such magnificent results in material prosperity as has the anthracite trade of Pennsylvania."

At the close of 1895 the trade was in a bad way. Attempts in previous years to restrict production to market needs and keep prices high enough to give a fair profit had failed, and the 1895 attempt was a worse failure than most of its predecessors. The sales agents in New York City at monthly conferences estimated what the market would take, but the output regularly exceeded the estimates, so that by November even the pretence of restriction was abandoned, every company being free to get out as much as it chose. The net result for the year was a record-breaking output, sold at prices which could have hardly been satisfactory. Conditions during 1896 were also unsatisfactory, though the railroads maintained prices fairly well and kept output in sight of market needs; but the country had not recovered from the effects of the panic of 1893 and people managed to get along with much less coal than the directing minds of the anthracite trade apparently thought possible, and at the end of the year the companies again had large unsold stocks on hand. At the opening of 1897 the producers resolved to restrict production still more, and for the first half of the year succeeded fairly well, but shipments though cut to below the figures of 1896, were still too much for the market. The sales agents' monthly estimates of what the market would take in 1896 made a total of 42,344,222 tons, while the actual shipments from the mines were 43,177,400; in 1897 the estimated tonnage needed was 38,159,200 tons, the shipments 41,204,800 tons. During much of 1898 the trade was demoralized. Anthracite prices did not reach the 1879 average—$3·30 for stove size f. o. b. New York Harbor—but by the end of the year were very low. In 1899 prosperity came to the anthracite as to other industries, and came quickly. Since 1899 strikes have interrupted production in two years, resulting in abnormal conditions, and the continued prosperity of the country has maintained demand.

During May, June and July, 1898, many mines in the Lackawanna and Wyoming regions worked but 5 days a month. The miners were dissatisfied, and the organizers of the United Mine Workers found ready listeners when they began to preach trade unionism in a region where trade unions had lost nearly all power after the defeat of the Knights of Labor in 1887. The independent mining companies,—those mining companies not controlled by a railroad,—were complaining that freight rates were too high, that the railroad companies were altogether too arbitrary in restricing car supply, though in the demoralized state

the collieries it acquired. The presidents of the railroads guaranteeing the stock and bonds of the company were made directors because they were most directly interested. They control a majority of the stock. The railroads guarantee the debt on a basis of the average percentage of the total shipments of coal from the anthracite fields each handled during several years prior to 1898; this being deemed the most satisfactory basis. It may be noted in passing that there are other men than Mr. Baer who believe that the interest of Simpson & Watkins in a projected railroad was largely a pretext to get better terms for their property. Certain it is that they received a very good price indeed.

The New York, Lake Erie & Western Railroad was reorganized as the Erie Railway in 1895. It had a shipping arrangement with the Delaware & Hudson Canal Co., but its own coal lands were in the northern part of the Lackawanna region, and its subsidiary Hillside Coal & Iron Co. was not a very important producer. The stock of the Erie Railway, except a few shares of common stock, was deposited in a voting trust; the three trustees, one of whom was J. P. Morgan, were to hold the stock until 1900 and thereafter, until a cash dividend of 4% had been paid on the first preferred stock.

In 1898 Mr. Morgan made the Erie Railroad a much more important factor in the anthracite trade by taking over the New York, Susquehanna & Western Railroad, which had been completed to the anthracite fields in 1894, after considerable litigation over rights of way, etc., with existing lines. The road was to take the tonnage of a number of independent operators about Scranton, who had pledged their tonnage on contracts calling for 50% of the tide-water selling price. The New York, Susquehanna & Western Railroad handled the output of the Jermyn collieries, and of several other companies, and in 1897 handled as an initial road 1,400,000 tons of coal. The Erie Railway paid for it by issuing stock, and exchanging nine-tenths of a share of its stock for one of New York, Susquehanna & Western.

Most of the independent operators were shipping under contracts by which they turned over their coal at the breaker to a coal and iron company controlled by a railroad company, receiving therefore 60% of the average selling price of the prepared sizes of free burning white-ash coal, f. o. b. New York Harbor during the preceding month. It is to be noted that the coal and iron company bought the coal outright at the breaker, and the 60% of the tide-water selling price was simply a measure of value. The coal of an independent operator bought under one of these contracts might be shipped to some nearby point, or to Chicago, Duluth or St. Louis, and the price which the railroad company received for it would then have nothing to do with the New York Harbor price. The sales contracts, therefore, were not shipping contracts, but purchase contracts pure and simple. However, many independent operators were much dissatisfied at the restrictions the railroads often put on output by short car supply, the railroads being hampered by the poor market in 1896, 1897 and 1898, and these operators, or some of them, projected another railroad to tide-water. This road was incorporated in 1899 as the Delaware Valley & Kingston, and was to run from Lackawaxen to Kingston along the Delaware & Hudson Canal, which the Delaware & Hudson Canal Co. had just abandoned as unprofitable after some 70 years of use. A

[illegible] of the tonnage to be shipped over the proposed road was to come from [illegible] of the Pennsylvania Coal Co., one of the few large concerns in the anthracite [illegible] to pay good dividends over a long term of years. This company owned [illegible] therefore paid no royalties. It had bought the lands at a time when [illegible] cheap, and its operations had been carefully managed. The company [illegible] owned the Erie & Wyoming Valley Railroad, running from Hawley [illegible] and this road was to be part of the projected Delaware Valley & [illegible] Railroad. The construction of the new road was vigorously opposed by [illegible] which had been hauling for something like 30 years the output [illegible] Coal Co.'s mines from the terminus of the Erie & Wyoming [illegible] Railroad. The Erie Railroad naturally objected to losing the haul of [illegible] annual tons of coal a year, and bitterly fought every step in the [illegible] and the Pennsylvania courts. This litigation delayed construction, [illegible] had been seriously interfered on the road, and finally in 1900 the [illegible] properties of the Pennsylvania Coal Co. and of the Delaware Val[illegible] Railroad. The purchase was made through J. P. Morgan & Co., [illegible] up the shares of the Pennsylvania Coal Co., paying therefore [illegible] and afterward transferred the shares to the Hillside Coal & Iron [illegible] by the Erie Railroad, taking payment in Erie Railroad bonds and [illegible] a profit of 61 millions on the deal. As the Pennsylvania Coal [illegible] out of it and as the market for anthracite had greatly improved, the [illegible] syndicate lost interest in a new railroad, and finally abandoned [illegible] when they made new sales contracts in 1901, by which they sold their [illegible] tonnage at 65% of the tide water price. The new contracts, however, [illegible]

[illegible] & Hudson Canal Co. [illegible] coal from Honesdale [illegible] to Pennsylvania points to the Erie Railroad, [illegible] from Honesdale to tide water at a much lower freight rate, [illegible] per ton] than the corresponding charges on coal from the anthracite mines to tide water. At present the [illegible] of coal to the Hillside Coal & Iron Co. on a [illegible]

[illegible] & Reading Railway was organized in [illegible] Wyoming [illegible] [illegible] [illegible]

Hartford Railroad, and thereby brought quick destruction on himself and his plans. Mr. McLeod's attempt was premature, but in the main soundly planned.

After the foreclosure in 1896 the capital stock of both the Philadelphia & Reading Railway, successor of the Philadelphia & Reading Railroad, and of the Philadelphia & Reading Coal & Iron Co. were acquired by the Reading Co., a Pennsylvania corporation. All the stock except 2,000 shares of common stock was deposited in a voting trust, with J. P. Morgan, F. P. Olcott and C. S. W. Packard as voting trustees, to be held until January 1, 1902, and thereafter until the first preferred stock should receive a 4% dividend for two consecutive years.

Speaking of the Reading Railroad, Mr. Rothwell has said: "There is no competitor in market so dangerous as a concern obliged to force its output and sell its product regardless of consequences, because while running it can get extensions of credit and can borrow money to carry it over to those better times which are always looming up on the horizon of every sanguine financier. The condition of unstable equilibrium, in which the finances of a number of the coal roads and companies have always been, could not withstand the additional burden which would be brought upon it by such demoralized markets as would result from the frantic struggles of a bankrupt competitor. Hence the companies have unwillingly been forced to hold together in an effort to support the market price of coal. Since the weakest financially, and consequently the most dangerous of the coal roads, is that which has the greatest natural advantages and elements of strength, it is evident that the controlling factor in this struggle lies not in natural advantages but in pre-eminent ability to borrow money. There is no doubt that if the Reading had abundant capital it would promptly take a very much larger proportion of the trade than it has, and would practically dictate to all its competitors or absorb them."

In reorganizing the Reading, Mr. Morgan and the men he represented were of course taking up a project out of which they expected to make money. Probably they, like Mr. Gowen and Mr. McLeod, saw the possibilities of the Reading system and of the anthracite coal trade; possessed of ample resources, all they needed to do was to take full advantage of the first rise of the next wave of industrial prosperity. The anthracite companies had wandered in the wilderness of mismanagement long enough and were looking for a Moses to lead them out. Consequently the house of J. P. Morgan & Co. met with no serious resistance in its plans, and public opinion was not aroused till later.

In January, 1901, the Philadelphia & Reading Railway took over 145,000 shares (a majority) of the stock of the Central Railroad of New Jersey for $23,200,000. J. P. Morgan & Co. bought the shares and charged a commission. The purchase gave the Reading a more direct entrance to New York, and also enabled Morgan interests to extend their holdings of coal lands, as the Central Railroad of New Jersey controls the Lehigh & Wilkes Barre Coal Co., which has collieries in the Wyoming Valley and in the Lehigh region. New York business of the Reading had gone over Central tracks for 30 miles, and the Reading hauled considerable bituminous coal to Allentown, Pa., whence the Central hauled it to New York.

A previous transfer of the Central Railroad of New Jersey to the Reading Co.

policy of the Delaware, Lackawanna & Western Railroad. Early in 1899 Mr. Samuel Sloan, the venerable president of the road, resigned, and was succeeded by Mr. W. H. Truesdale, who had shown high ability as a railroad manager. His coming was followed by many changes in the officials, some of whom had held their places for years, by a more open attitude of the directors toward the stockholders, and apparently by a changed policy regarding output and prices.

The New York, Ontario & Western Railroad, when it built a 54-mile branch to Scranton in 1890, had no direct control of anthracite mines, and its contracts with individual operators did not insure tonnage. To insure tonnage it did what other railroads had done, advanced money to operators to open mines, and later bought a majority of the stock of the Elkhill Coal & Iron Co. and of the Scranton Coal Co., and advanced money to these companies to buy mines, including those of the Lackawanna Iron & Steel Co. In this way between 1898 and 1901 it secured indirectly over 80% of the producing capacity of the mines it reaches. The stock of the New York, Ontario & Western is largely held in England, and its directors though willing enough to support any policy that would increase the road's earnings, have always acted rather independently. The Vanderbilts are believed to own stock in the road, which ships to New York harbor from Cornwall over the tracks of the West Shore, a Vanderbilt line.

The Pennsylvania Railroad has been interested in anthracite through its subsidiary Susquehanna Coal Co. with mines near Nanticoke in the Wyoming region, and through the Union Coal Co. and the Mineral Hill Railroad & Mining Co., with mines in the western part of the Schuylkill region. The company has always given attention to hauling bituminous coal, and has had little to do with any attempt to restrict the production or uphold the price of anthracite. When Mr. Morgan started to control the anthracite situation he met with little or no opposition from the Pennsylvania, and the opinion prevailed that Mr. Morgan and the Vanderbilt roads were to take care of anthracite, and the Pennsylvania Co. was to look out for bituminous trade. After the Pennsylvania Railroad had secured large interests in the stocks of the Norfolk & Western, Chesapeake & Ohio, and Baltimore & Ohio (in 1899), there was no apparent change in the Pennsylvania's attitude until 1902. In the spring of 1903 the announcement was made that the banking house of Kuhn, Loeb & Co. had purchased in open market almost a controlling interest in the Reading Co., 1,300,000 shares out of 2,800,000, mostly first preferred stock. Why this purchase was made is a matter of doubt. Possibly it was an outcome of the fight between the Pennsylvania and Wabash systems, Mr. Morgan having no objection to selling out his Reading holdings at a profit and the Pennsylvania and the Vanderbilt railroads wishing to keep the Wabash from getting control of the Reading. The stock acquired by Pennsylvania and Vanderbilt interests was taken over by the Baltimore & Ohio Railroad, a Maryland corporation, for the Pennsylvania Railroad and by the Lake Shore Railroad for the Vanderbilts. Thus conflict with that clause of the Pennsylvania constitution forbidding the consolidation of competing lines was avoided. At the same time J. P. Morgan & Co. increased their holdings of Erie.

The house of J. P. Morgan & Co. having secured a commanding position in the

SHIPMENTS FROM THE ANTHRACITE REGIONS (TONS OF 2,240 LB.) AND PERCENTAGE OF COAL HANDLED BY EACH ROAD AS AN INITIAL LINE.

Coal Roads.	1895.		1896.		1897.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Philadelphia & Reading	9,905,059	21·23	9,019,583	20·89	8,395,411	20·2
Central of New Jersey	5,388,194	11·58	4,999,003	11·58	4,730,860	11·4
Lehigh Valley	7,360,454	16·82	6,749,128	15·63	6,425,227	15·4
Del., Lack. & Western	6,129,261	13·17	5,627,533	13·03	5,696,684	13·7
Delaware & Hudson	4,347,843	9·35	4,152,273	9·62	5,646,853	13·5
Pennsylvania R.R.	5,025,645	10·80	4,752,120	11·16	.....	.....
Pennsylvania Coal Co.	1,746,882	3·76	1,728,972	4·05	1,777,841	4·3
Erie	1,820,038	3·91	1,718,202	3·98	.....	.....
N. Y., Ontario & Western	1,424,407	3·07	1,321,895	3·06	.....	.....
Del., Susq. & Schuylkill	1,905,784	4·10	1,698,684	3·93	.....	.....
N. Y., Susq. & Western	1,492,244	3·21	1,410,080	3·27	.....	.....
Total	46,511,476	100·00	43,177,485	100·00	41,637,864	100·00

Coal Roads.	1898.		1899.		1900.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Philadelphia & Reading	8,219,814	19·6	9,668,503	21·21	9,388,516	.....
Central of New Jersey	4,626,386	11·0	5,392,550	11·31	5,309,856	.....
Lehigh Valley	6,885,577	16·5	7,588,982	16·62	6,909,442	.....
Del., Lack. & Western	5,795,540	13·8	.....	.....	6,013,849	.....
Delaware & Hudson	5,613,186	13·4	.....	.....	3,973,859	.....
Pennsylvania R.R.	.....	.....	.....	.....	5,169,947	.....
Pennsylvania Coal Co.	1,854,515	4·4	.....	.....	.....	.....
Erie	.....	.....	.....	.....	5,165,070	.....
N. Y., Ont. & Western	.....	.....	.....	.....	1,668,457	.....
Del., Susq. & Schuylkill	.....	.....	.....	.....	1,568,498	.....
Total	41,879,751	100·00	47,665,208	100·00	45,107,484	100·00

In the year 1886–1896 the highest and lowest percentages handled by the railroads were: Reading, highest 21·84, lowest 20·30; the Lehigh Valley, highest 21·12, lowest 13·86; Central of New Jersey, highest 17·10, lowest 11·58; Delaware, Lackawanna & Western, highest 18·42, lowest 13·03; Delaware & Hudson, highest 11·84, lowest 9·08; Pennsylvania Railroad, highest 13·57, lowest 9·28.

anthracite trade could put through any plan which seemed likely to benefit the railroads, make mining more profitable, and insure steadier work at the mines. As has been pointed out time and again, the anthracite trade has suffered not only from the persistent tendency of operators to mine and market more coal than the public could take at a profitable price, but also from irregular demand. Anthracite being a domestic fuel is most wanted in winter, while from April to September but little coal is required. A demand, heavy during a few months and then very light, has made the working time of miners correspondingly irregular, with the result that though wages have been high, yearly earnings have sometimes been woefully small. The wages have attracted many men to the field with the resulting conditions that the Anthracite Strike Commission discusses in its report.

As irregular work at the mines is more expensive than steady operation, the mining and railroad companies have sought to keep the mines running more steadily by storing coal during the slack months—June, July and August, long known as the time of "midsummer dullness." This, however, gave little relief to the independent operators since the railroad could hardly be expected to help an independent at the cost *of rehandling his coal*, and the companies themselves *aside from the expense and waste in storing* coal, according to Mr. Baer, 20c.

per ton for the Reading, have often found this stored coal a demoralizing factor in a weak market.

A new plan proposed in the spring of 1901 resembled somewhat a plan suggested years before which had failed for the same reason that caused the failure of so many other plans to make the trade profitable, the lack of good faith among officers of the companies. The new schedule of prices was on a basis of $4.50 per ton for stove and chestnut sizes of free-burning white ash coal f. o. b. New York harbor, with egg, $4.25 and broken $4. A discount of 50c. per ton was to be given on all coal delivered in April, 40c. in May, 30c. in June, and so on till basis prices were reached Sept. 1. In connection with this plan, a most excellent one for insuring a more even distribution of buying, and thereby steadier work at the collieries, the Reading undertook the reform of another abuse, by making prices the same to large and small dealers, and doing away with many commission sales agencies. This meant a saving in commissions, and the removal of the influence of the jobbers and speculators who by buying at discounts, perhaps of some relative connected with a coal company, had helped demoralize market conditions. It is to be noted that all the companies announced the same prices and the same discounts for the same grades of prepared sizes. This at first sight

CIRCULAR AND SELLING PRICES OF STOVE COAL F. O. B., NEW YORK HARBOR, BY MONTHS, 1895–1902.

Month.	1895.		1896.		1897.		1898.	
	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.
January	$3.60	$3.36	$3.75	$3.28	$4.25	$3.87	$4.50	$3.74
February	3.60	3.28	3.75	3.24	4.25–4.10	3.91	4.00	3.84
March	3.60	3.15	3.75	3.44	4.25	3.92	4.00	3.88
April	3.35	3.05	3.75	3.55	4.25	3.98	4.00	3.88
May	3.35	3.00	4.00	3.60	4.25	3.95	4.00	3.91
June	3.35	2.87	4.00	3.66	4.25–4.10	3.97	4.00	3.91
July	3.35	2.80	4.25	3.81	4.50	3.99	4.00	3.85
August	3.35	2.75	4.25	3.99	4.50	4.01	4.00	3.80
September	3.55	3.10	4.50	3.98	4.50	4.08	4.00	3.72
October	3.87	3.28	4.50	4.06	4.50	4.00	4.25	3.64
November	4.00	3.40	4.50	4.14	4.50	3.91	4.25	3.60
December	4.00	3.28	4.50	3.97	4.50	3.78	4.25	3.56
Average	3.58	3.11	4.15	3.72	4.37	3.94	4.10	3.75

Month.	1899.		1900.		1901.		1902.	
	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.
January	$4.25	$3.54	$4.40	$4.02	$4.00	$4.48	$4.50	$4.50
February	4.25	3.57	4.40	3.96	4.50	4.42	4.50	4.48
March	4.25	3.56	4.40	3.84	4.50	4.28	4.50	4.48
April	4.25	3.62	3.90	3.72	4.00	3.90	4.00	3.99
May	3.75	3.64	3.90	3.71	4.10	4.01	4.10	4.10
June	3.75	3.66	3.90	3.70	4.20	4.12	4.20	4.20
July	4.00	3.72	4.25	3.69	4.30	4.23	4.30	.....
August	4.00	3.75	4.25	3.73	4.40	4.34	4.40	.....
September	4.00	3.83	4.25	3.84	4.50	4.40	4.50	.....
October	4.25	3.93	4.25	4.28	4.50	4.45	4.50	.....
November	4.25	3.97	4.50	4.41	4.50	4.47	5.00	5.00
December	4.25	4.03	4.50	4.44	4.50	4.48	5.00	5.00
Average	4.10	3.73	4.24	3.83	4.37	4.32	4.46	.....

The above table shows quite plainly the wide divergencies between list quotations and the actual selling prices in the year prior to 1900. It will be seen that the strike of September, 1900, brought selling prices up to quotations. During the long strike of 1902, the companies nominally adhered to regular quotations, but had little coal to sell after June, and the f. o. b. price given is that of "speculative" coal—coal sold by independent operators or brought to New York from other markets.

a combination in restraint of trade, a violation of the Sherman act. A newspaper here actively denounced the plan. Mr. Baer, however, has said that he announces what proves the Reading Co. will ask for, and the presidents of the other companies follow his lead. He said a president of another company would be foolish to sell for less with demand as it has been for the past two years. This is, of course, so, but there is the fact that several of the anthracite railroads are owned by independent companies, and these that are not have no desire to fight. In short, the only weak spot in the sales system that it has yet to stand the test of depression.

The roads as they are to-day, therefore, we find the Pennsylvania controlling stock in the Norfolk & Western, the Chesapeake & Ohio, Ohio & Ohio railroads, which with it transport 90% of all the bituminous coal for the Atlantic seaboard. The Reading Co. owns 53% of the Central Railroad of New Jersey, and with the Erie, the Delaware, Lackawanna & Western, and the Pennsylvania owns a large amount of Lehigh Valley stock. A controlling interest in the first preferred stock of the Lehigh is held by the Baltimore & Ohio Railroad, controlled by the Pennsylvania Railroad, and by the Lake Shore Railroad, a Vanderbilt road. The Vanderbilts have large holdings in the Delaware, Lackawanna & Western, and control the Delaware & Hudson Co., while the output of the Delaware & Hudson is controlled by the Erie, a Morgan railroad. Recently there have been [illegible] operations on the Stock Exchange, and it is not known [illegible] Lehigh Valley Railroad stock has been secured by men interested [illegible] but with Mr. Morgan the Vanderbilts and the stockholders [illegible] Railroad acting in harmony to make the anthracite industry [illegible] in the management of the [illegible] been. There is a [illegible] sales agents agree- [illegible] presidents agreeing on output. The presidents [illegible] past, but knowing the history of the trade [illegible] are held, they are not [illegible] [illegible] [illegible]

It is frequently said that the anthracite railroads habitually violate the new Constitution of the State of Pennsylvania, adopted in 1874. Article XVII. of the Constitution says, "No incorporated company doing business as common carrier in the State shall, directly or indirectly, engage in mining or manufacturing articles for transportation over its works." But this same Article XVII. makes no further provision for companies already chartered than to say that "no railroad, canal or other transportation company in existence at the time of the adoption of this article shall have the benefit of any future legislation by general or special laws, except on condition of complete acceptance of all the provisions of this article." The Pennsylvania courts have held that charters granted by the State are inviolate, and that the Constitution is not retroactive. Hence the prohibition does not apply to companies incorporated twenty or thirty years before, like the Delaware, Lackawanna & Western, or Delaware & Hudson, the latter a New York corporation. In the case of the Reading the situation is this: The mortgagee's committee that bid in the road at the foreclosure of 1896 secured the charter of the National Enterprise Co., incorporated in 1871, changed its name to the Reading Co., increased its capitalization, and transferred to it all the capital stock of the Philadelphia & Reading Railroad and the Philadelphia & Reading Coal & Iron Co. The reorganization of the railroad involved its recognition of the new Constitution, but the franchises of the Coal & Iron Co. were expressly excepted in the sale, since recognition of the Constitution would have taken from that company the right to hold over 10,000 acres of land. The Reading Co.'s charter antedates the new Constitution. Thus it happens that while the Philadelphia & Reading Railway has accepted the Constitution, the Reading Co. and the Philadelphia & Reading Coal & Iron Co. have not.

Further, it may be said that State laws have empowered railroad companies to purchase the stock of coal and iron companies, and, according to a ruling of the Supreme Court there is no limit on the amount of stock the railroad may own. The distinction between indirectly mining coal and controlling a coal mining company is a pretty fine one, but the Pennsylvania courts have made it.

Writing in 1896, Mr. Rothwell said: "The natural evolution of the industry has always been in the direction of the union of the business of mining and of transporting, and its concentration into fewer and fewer hands, and this tendency will undoubtedly continue. The financially strong will devour the weak, and the control of nearly all the coal lands and mines by the coal roads will lessen the chance of new roads being projected to secure this coveted tonnage. Agreements or devices to regulate prices will become less important as the concentration of interests goes on and as the available supply of anthracite diminishes."

The present condition of the industry shows that the time when agreements would be unnecessary was nearer than Mr. Rothwell supposed. Viewed in this light the evolution of the anthracite coal trade is not likely to be affected greatly by anti-trust legislation. Unless the United States is rushing pell mell into socialism, with State ownership of all mines, railroads, industrial establishments and land, the anthracite trade in the future, as in the past, will be governed by the working of that inexorable law that controls the growth of corporations or industries, as it controls the development of organisms—the law of the survival

[illegible] will follow prosperity as the trough of the wave follows the crest. Anthracite prices just now are influenced by a wide demand [illegible] seasonal support cannot, in times of depression, long maintain [illegible] and strength in anthracite coal, through increasing competition from bituminous coal and through the increased cost of production as [illegible] are exhausted, will undoubtedly sell at higher average prices in the near future than is necessary to induce that present prices will be maintained. Sooner or later they will fall, though probably not to the [illegible] to the level of January, 1908. Ultimately, it is likely that [illegible] of marketing the fuel and the present wastes in its use will be [illegible] the utilization of coal at the mines and the transmission of its [illegible]

By-Product Coke Ovens.

By F. Schniewind. [1]

The development of the by-product coke oven in the United States is progressing satisfactorily, as is indicated by the subjoined table which gives the number of ovens of this type operative or in course of construction in the United States and Canada during 1902.

BY-PRODUCT COKE OVENS IN THE UNITED STATES AND CANADA IN 1902.

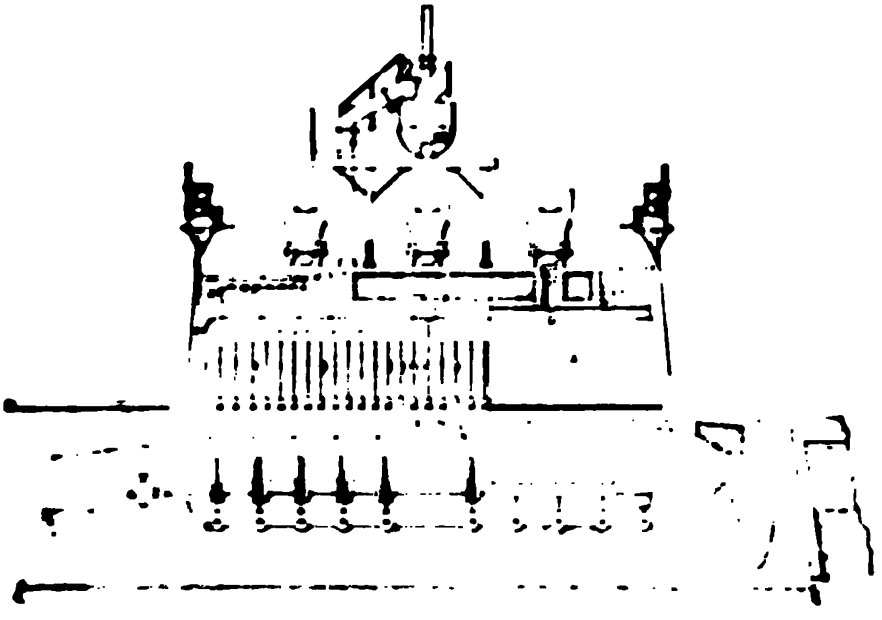
Company.	Location.	No. of Ovens.	Use of Coke.	Use of Gas.
Otto-Hoffmann ovens:				
Cambria Steel Co. (a)	Johnstown, Pa.	100	Blast furnace	Fuel.
Cambria Steel Co.	Johnstown, Pa.	160	Blast furnace	Fuel.
Pittsburg Gas & Coke Co.	Glassport, Pa.	120	Blast furnace and domestic	Illum. and fuel.
New England Gas & Coke Co.	Everett, Mass.	400	Domestic and locomotive	Illuminating.
Dominion Iron & Steel Co., Ltd.	Sydney, C. B.	400	Blast furnace	Fuel.
Hamilton Otto Coke Co.	Hamilton, O.	50	Foundry and domestic	Illuminating.
Lackawanna Iron & Steel Co.	Lebanon, Pa.	232	Blast furnace	Fuel.
Lackawanna Iron and Steel Co. (a)	Buffalo, N. Y.	564	Blast furnace	Fuel.
South Jersey Gas, Electric & Traction Co.	Camden, N. J.	100	Foundry and domestic	Illuminating.
Maryland Steel Co.	Sparrows Point, Md	200	Blast furnace	Illum. and fuel.
Michigan Alkali Co.	Wyandotte, Mich.	15	Burning lime	Fuel.
Sharon Coke Co. (a)	Sharon, Pa.	212	Blast furnace	Fuel.
Zenith Furnace Co. (a)	Duluth, Minn.	50	Blast furnace and foundry	Illuminating.
Semet-Solvay ovens:				
Solvay Process Co.	Syracuse, N. Y.	30	Lime kilns	Fuel.
Semet-Solvay Co.	Dunbar, Pa.	110	Blast furnace	Fuel.
National Tube Co.	Benwood, W. Va.	120	Blast furnace	Fuel.
Semet-Solvay Co.	Ensley, Ala.	240	Blast furnace	Fuel.
People's Heat & Light Co.	Halifax, N. S.	10	Domestic	Illum. and fuel.
Solvay Process Co.	Delray, Mich.	120	Lime kilns	Fuel.
Philadelphia Suburban Gas Co. (a)	Chester, Pa.	40	Blast furnace	Illuminating.
Central Iron & Coal Co. (a)	Tuscaloosa, Ala.	80	Blast furnace	Fuel.
Pennsylvania Steel Co. (a)	Lebanon, Pa.	90	Blast furnace	Fuel.
Milwaukee Coke and Gas Co. (a)	Milwaukee, Wis.	80	Blast furnace and foundry	Illuminating.
Newton Chambers ovens	Pocahontas, Va.	60	Blast furnace	
Retort Coke ovens:				
Cleveland Furnace Co. (a)	Cleveland, O.	66	Blast furnace	Illum. and fuel.
Total		3,649		

(a) In course of construction.

The production of coke in 1901 from by-product ovens amounted to 1,179,900 tons, valued at $2,894,077, or about 5% of the total quantity of coke produced. The average yield per oven in 1901 was 1,000 tons of coke. The by-products included 12,659,150 gal. tar, 12,927,627 lb. ammonium sulphate and 2,537,510 gal. ammonia liquor, aggregating in value $1,029,876. The quantity of gas produced is estimated at 12,000,000,000 cu. ft., worth $3,000,000. From these statistics, the importance of this special branch of manufacture may be appreciated.

The number of ovens erected or in course of erection during 1902 was 3,649, as compared with 3,278 ovens in 1901. Of the former total, 2,603 ovens are of the Otto-Hoffmann type, and 920 are Semet-Solvay ovens. The tendency of the present time is to increase the capacity of the ovens, and the new ones of the United Coke & Gas Co., erected during the year, are 43 ft. 8 in. long, 6 ft. 6 in. high, and 17 in. wide. Of the 3,649 ovens referred to above, all are practically completed with the exception of the plant of the Lackawanna Steel Co., at Buffalo, N. Y., and the plant for the Zenith Furnace Co., at Duluth, Minn. The Semet-Solvay Co. is also increasing the size of its ovens, and five horizontal flues are now being used in the side walls instead of the three originally used.

[1] Supplementing the article by F. Schniewind, on "The Manufacture of Coke in the United States with Special Reference to the Markets for By-Products," The Mineral Industry, Vol. X., pp. 135-174.



oven and the Otto-Hoffmann and Otto-Hilgenstock oven being summed up as follows: (1) The introduction of the underfired principle in connection with the use of regenerators; (2) the use of a columnar substructure instead of brick arches, admitting anchorage rods beneath the ovens to facilitate complete inspection while in operation; (3) the entire separation of the regenerative chambers from the frame work supporting the ovens. The Schniewind oven can be more easily watched, the heats can be better controlled, and the length can be increased from 33 to 43 ft. An 8-ton charge can be treated in place of a 6-ton one, with a corresponding decrease in the operating costs per ton of output.

Mr. E. A. Moore, of the United Coke & Gas Co., has designed a new form of quenching car, whereby the coke is cooled with a minimum amount of water, and its silvery luster preserved. The coke can be handled directly to the railroad cars. The car is covered, and receives the charge of coke directly from the oven, quenching it by water supplied to nozzles placed inside. The top and sides

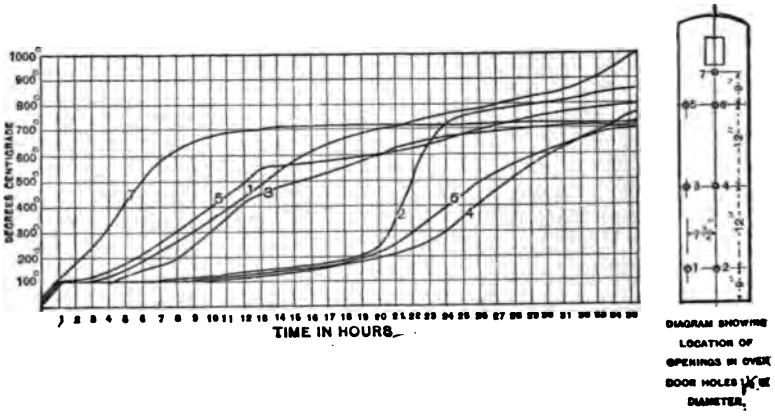


FIG. 2.—DIAGRAM SHOWING THE TEMPERATURE OF THE OVEN CHARGE AT DIFFERENT POINTS.

of the car are of cast-iron plates, so that the steam is confined and assists in the quenching operation. The bottom of the car is movable in order that the coke may be discharged from the car with ease.

A series of tests was made at Sydney on the progress of coking in the oven. Holes were bored in the oven door at various points, as shown in Fig. 2, and temperatures were taken at intervals during the coking period. These temperatures were plotted by means of curves, as shown in Fig. 2, which group themselves into two classes, those very near the heating walls rising rapidly, and those in the middle of the oven charge remaining at a lower temperature, between 100° and 200°C., until some time has elapsed, when they rise rapidly as the coking becomes complete. The diagram shows that the gasification begins at the oven walls and that it proceeds gradually from the wall toward the center; also that the evolved gases pass upward along the wall and through the fissures in the coked portion. During the passage of the gas it has an opportunity to deposit a certain portion of its carbon in graphitic form, which accounts in part

increased yield of the by-product oven over that of the beehive type. The coke ovens obtained by C. Otto & Co. when carrying out a similar series of experiments on the two ovens being almost identical.

Building of coke ovens in Germany in 1907 showed continued progress. According to the annual report of the Chief Inspector of Alkali Works, etc., United Kingdom, several improvements have been made in the use of gas of the Semet-Solvay type in the steel works. The washed fine coal, being delivered to the ovens, is moulded into cakes by means of a compressor worked by coke-oven gas. One-fourth more coal can be charged into the oven, the charging is shortened, and a gain of 10% in the yield is obtained. Steam is also used to quench the coke of incandescent coke, by which the value of the resulting coke is increased. The time of carbonizing is now more regular by controlling the draught by means of a fan connected with the chimney. During 1907, five plants with 165 ovens have been constructed by the Semet-Solvay Coke Oven Co., Ltd., the ovens all being of the Hilgenstock regenerative underfired type.

COPPER.

By Joseph Struthers, D. H. Newland and Henry Fisher.

The production of copper in the United States during 1902 amounted to 610,815,384 lb., as compared with 597,443,212 lb. in 1901, an increase of 13,372,172 lb. resulting from increased activity throughout all of the copper mining districts in the United States excepting Arizona and California.* The greatest increase was from the Michigan mines, followed by those in Montana. Detailed as to principal States, the production of copper during 1902 contrasted with that of 1901 was as follows: Montana 240,050,000 lb. as compared with 229,870,415 lb. in 1901; an increase of 10,179,585 lb.; Michigan 170,663,999 lb. as compared with 155,511,513 lb. in 1901; an increase of 15,152,486 lb.; Arizona 119,841,285 lb. as compared with 126,183,744 lb. in 1901, a decrease of 6,342,459 lb., and California 25,038,724 lb. as compared with 33,667,456 lb. in 1901, a decrease of 8,628,732 lb.

According to the reports of the American copper refiners, the quantity of copper refined electrolytically during 1902 was approximately 80% of the total production. The output of copper sulphate during 1902 was 48,763,538 lb. as compared with 78,004,257 lb. in 1901, a decrease of 29,240,719 lb. The average price of copper sulphate during 1902 was 4·16c. per lb. as compared with 4·1c. per lb. in 1901. Of the total production of copper sulphate during 1902, the quantity recovered as a by-product was 35,879,212 lb. as compared with 51,000,000 lb. so produced in 1901, while that produced direct from ore was 739,801 lb. as compared with 204,095 lb. in 1901.

The stock of copper on hand at the end of 1902 was 144,905,600 lb. as compared with 209,587,698 at the end of 1901.

The imports of copper during 1902, as reported by the smelting and refining companies and the United States Treasury Department were 161,551,040 lb. as compared with 176,472,369 lb. in 1901, while the exports during 1902 were 369,402,880 lb. as compared with 227,194,184 in 1901. As given in detail later in this section, the price of Lake copper during 1902 averaged 11·887c. per lb. as

* *The statistics of production do not include copper recovered in the form of copper sulphate.*

ploitation on a commercial scale is dependent upon the construction of a railroad which it is thought would offer no serious difficulties.

Arizona.—(By James Douglas.)—The works of the Calumet and Arizona Co. at Douglas were started in November, 1902, with an output of from 20 to 25 tons of copper per day, which will be increased during 1903. The Shannon Co. in the Clifton district closed its smelters after a short campaign in order to sup-

COPPER PRODUCTION IN ARIZONA. (*a*) (POUNDS OF FINE COPPER.)

Mines.	1897.	1898.	1899.	1900.	1901.	1902.
Arizona Cop. Co....	13,727,911	18,169,096	19,072,709	19,697,086	20,535,800	30,821,842
Calumet & Arizona						2,066,647
Copper Queen.....	23,999,873	33,749,390	36,901,694	34,382,809	39,781,333	35,851,755
Detroit.....	8,405,138	11,428,992	13,906,258	10,749,258	17,535,000	18,721,411
Old Dominion.....	2,000,000	1,800,000	6,900,000	7,155,000	10,094,900	7,992,550
United Verde.....	31,355,025	42,828,926	43,995,982	39,970,193	34,520,695	19,407,080
United Globe.....	1,241,975	2,847,460	4,451,180	*Nil.*	890,100	*Nil.*
Other mines.....	290,000	*e* 500,000	*e* 750,000	*e* 3,450,000	*e* 2,896,516	*e* 5,000,000
Totals.....	81,019,922	110,823,864	125,377,758	115,403,846	126,183,744	119,841,285

(*a*) Reported by producers direct to THE MINERAL INDUSTRY. (*e*) Estimated.

plement the works with a concentrator of 500 tons daily capacity; when operations are resumed the production of copper will probably amount to 300 tons per month. In Yavapai County the Val Verde Co. is active and is producing a copper matte rich in gold and silver. The Black Diamond Co., operating in the Dragoon Mountains, expects to start a 100-ton furnace early in 1903. The older companies are showing no symptoms of decay. The new Copper Queen works at Douglas should start during the present summer; they are designed to take custom ores of copper, gold and silver, as well as a slightly larger tonnage from the mines of the company. The works are to be supplied with large furnaces and good engines, and planned so as to handle large quantities of fuel and ore by machinery. The removal of the works to a distance of 28 miles from the mines was made to secure space for an enlarged and better designed smelter, water for high-class condensing engines, nearer proximity to fuel, a location more central to the mines of the Phelps-Dodge properties, and to facilitate the purchase of ores from Mexico and the Southwest. There is no intention of invading the market for lead, but the company will enrich the copper bullion with gold and silver. The completion of the El Paso & Southwestern Railroad, and the extension of the Nacosari Railroad into Sonora from Douglas, makes this town a favorable center for metallurgical works, which may hope to secure ores from Mexico and from the reopened mines of Tombstone. The latter are being revived by the Development Co. of America, and have been reached by a branch of the El Paso & Southwestern Railroad. Recent exploration in depth in the mines of the Old Dominion and the United Globe companies reveal sulphides in quantity of a grade that promises to give life to the mines, and, it is hoped, a better smelting mixture. The United Verde mines should show an increased production in 1903. During the past year this company earned net profits of $927,651. In the Clifton district the Arizona and Detroit companies are aiming rather at increased efficiency in operation and lower cost of production than at making more copper, assured as they are of the

[illegible] and increasing in the future value of the metal. The [illegible] during the year ending Sept. 30, 1902, earned [illegible] of £183,225 from the mines and £11,662 from the railroad, a total [illegible]. Payments for mine administration were £13,888, for railroad [illegible], [illegible], interest, £25,218, reserve, £10,000, dividends [illegible] £24,531, leaving a net balance of £181,910 in addition to £14,610 brought forward from the previous year. Out of the [illegible] £196,520, a dividend of £160,000 or 8s. 6d. per share [illegible] preferred shares and the sum of £15,000 carried forward to [illegible]. The total quantity of ore treated in the mill was 195,849 [illegible] of concentrates. The ore and concentrates smelted [illegible] while the leaching plant handled 15,721 tons of tailings [illegible]. The copper ores treated was 1.17%, a decrease from the previous [illegible] was due in part to the reduced output of first-class ores and [illegible] lower quality of the concentrating ores. In the Bisbee [illegible] most promising feature of the year's development has been [illegible] ore bodies in the deeper limestones, in the [illegible] Copper Queen and the Calumet & Arizona companies [illegible] ore bodies over a large area has been proved.

The Red Hill mines in Shasta County have been consolidated [illegible] the Mountain Copper Company and are to [illegible] the latter title. These mines are situated about 25 miles [illegible] the same geological belt as the deposits owned by [illegible]. The ore bodies are composed of pyrite and chalcopyrite [illegible] and traces of carbonate and native copper. The [illegible] Red Hill [illegible] the Mountain [illegible] Mountain [illegible] [illegible] total [illegible] the [illegible]

Devils district during 1902 were limited practically to development work. The White Knob Copper Co. completed the construction of its smelting plant at Mackay, and it is expected that production will begin early in the present year. A large quantity of ore assaying about 9% Cu and $3 gold and silver per ton has been opened preparatory to an active campaign.

Michigan.—(By D. H. Newland.)—Despite the low prices of copper that prevailed during 1902, the mines on the Upper Peninsula made the largest output yet recorded. The increase over the preceding year amounted to about 10%, and was contributed in most part by the new mines, *viz.:* the Baltic, Trimountain, Champion, Isle Royale, Arcadian, and Mohawk, whose combined production exceeded 20,000,000 lb. The larger properties made no advance in respect to output, although improvements in both mines and mills materially strengthened their position for continued profitable working. It is expected that the output in 1903 will reach a still larger total, due to the more extended operations of the new producers. The production of all the mines during the past six years was as follows:—

COPPER PRODUCTION IN MICHIGAN. (POUNDS OF FINE COPPER.)

Mines.	1897.	1898.	1899.	1900.	1901.	1902.
Arcadian	*Nil.*	*Nil.*	500,000	*e* 800,000	*e* 1,000,000	*e* 500,000
Atlantic	5,109,663	4,377,399	4,675,882	4,930,149	4,666,899	4,949,388
Baltic	*Nil.*	42,766	603,570	1,735,060	2,641,432	6,285,819
Calumet & Hecla	88,378,966	94,103,000	98,002,137	81,403,041	82,519,676	81,248,739
Central	611,172	291,339	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Champion	.....	.....	.....	.....	.....	4,165,784
Franklin	2,908,384	3,568,978	1,290,000	3,663,710	3,757,419	5,259,140
Isle Royale	*Nil.*	*Nil.*	*Nil.*	*Nil.*	2,171,955	3,569,748
Mass	24,061	*Nil.*	61,000	*Nil.*	*e* 800,000	2,345,805
National	28,959	18,441	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Osceola Consol'd	9,500,000	11,800,000	10,950,000	11,200,000	13,723,571	13,416,396
Quincy	16,924,618	16,354,061	14,301,182	14,116,551	20,540,720	18,998,491
Ridge	12,590	.....	(a)	(a)	(a)	(a)
Tamarack	20,000,000	22,500,000	17,750,000	18,400,000	18,000,852	15,961,598
Trimountain	.....	.....	.....	.....	.....	*e* 6,000,000
Wolverine	2,316,296	4,548,114	4,789,015	4,778,899	4,946,196	6,473,181
All other mines	25,000	*e* 25,000	2,983,000	3,200,000	788,898	1,500,000
Totals	145,839,749	156,669,098	155,845,786	144,227,340	155,507,465	170,663,999

(a) Consolidated with Mass. (*e*) Estimated.

In the subjoined table will be found the results obtained by ten leading mines, their capitalization, profits and itemized costs for the period 1898-1902. Similar information relating to previous years is included in THE MINERAL INDUSTRY, Vols. I., IX., and X.

CALUMET AND HECLA MINING CO.

Year.	Capital Paid In.	Real Estate. Amount Invested.	Personal Estate. Amount Invested.	Debts.	Credits.	Copper Produced Lbs.	Yield. (*b*) %	Average Price per lb. (*a*)	Estimated Receipts.	Dividends.
	$	$	$	$	$			$	$	$
1898	1,200,000	14,223,895	4,184,321	2,235,543	6,280,589	94,103,000	3·07	12·01	11,301,770	5,000,000
1899	1,200,000	14,032,991	7,215,716	2,298,467	1,669,622	98,002,137	.....	16·93	15,788,168	10,000,000
1900	1,200,000	16,545,511	3,092,768	(*c*)	1,676,766	81,403,041	(*c*)	(*c*)	(*c*)	7,000,000
1901	1,200,000	(*c*)	(*c*)	(*c*)	(*c*)	82,519,676	(*c*)	(*c*)	(*c*)	4,500,000
1902	1,200,000	(*c*)	(*c*)	(*c*)	(*c*)	81,248,739	(*c*)	(*c*)	(*c*)	2,500,000

(*a*) Prices obtained by taking the average prices realized by the other leading mines, including Quincy, Tamarack, Atlantic and Wolverine. (*b*) Computed from the shipments of freight over the Hecla and Torch Lake Railroad. On this basis the yield in 1875 was 4·30%; in 1891, 3·13%; and in 1898, 3·09%. (*c*) Not given in report of the company.

ATLANTIC MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Cost of Ton of Ore Stamped.						Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit.	
							Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage			Per Pound.	Per Ton, Milled.
	$	Tons.	Lbs.	%	Cts.	$	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$	Cts.	$
1898 ..	980,000	370,767	4,377,399	0·590	11·83	518,219·14	66·77	5·55	22·34	24·11	19·18	16·04	13·01	1·54	—1·18	—0·14
1899 ..	980,000	380,781	4,575,882	0·614	17·15	802,804·51	78·58	6·50	25·02	23·32	20·62	17·04	13·93	1·71	3·22	0·40
1900 ..	980,000	410,674	4,930,149	0·600	16·41	809,177·00	76·85	6·92	26·73	24·70	27·75	14·70	14·80	1·78	1·61	0·19
1901 ..	980,000	409,124	4,666,889	0·570	15·76	747,177·32	82·87	7·68	27.67	21·98	46·72	14·07	17·73	2·02	—1·97	—0·20
1902 ..	980,000	446,098	4,949,368	0·555	11·88	588,300·73	69·34	5·97	19·81	25·09	4·58	14·11	13·37	1·35	—1·59	—0·03

BALTIC MINE.

							(*k*)									
1898 ..	1,000,000	35,411	603,570	0·853	16·98	107,806·261·7		15·00	100·0	40·00	.....	.....	.....	.....	.....	.....
1900 ..	1,000,000	85,598	1,735,060	0·979	16·49	297,180	160·0	15·52	63·9	41·40	.....	29·60	.....	.....	.....	.....
1901 ..	1,000,000	114,703	2,641,429	1·150	16·43	442,551	171·3	14·99	53·13	41·08	391·0	33·57	.....	(*m*)	.....	.....
1902 ..	1,000,000	275,175	6,285,819	1·142	11·87	746,276·02	126·7	16·11	7·77	22·30	107·7	32·06	13·67	312	—1·80	—0·41

CHAMPION MINE.

							(*k*)									
1902 ..	2,500,000	120,485	4,165,784	1·73	11·82	492,553·36	(*d*)	(*d*)	(*d*)	(*d*)	579·22	52·21	27·92	965	—16·1	—5·57

FRANKLIN MINE.

							(*a*)	(*b*)								
1898 ..	2,000,000	116,696	2,623,702	1·12	12·07	317,917·63	177	(*d*)	(*d*)	51·02	(*d*)	34·29	9·39	2·11	2·68	0·61
1899 ..	2,000,000	89,789	1,230,000	0·68	16·48	202,647·81	(*d*)	(*d*)	(*d*)	32·90	(*d*)	32·28	(*d*)	(*d*)	(*d*)	(*d*)
1900 ..	2,000,000	268,571	3,663,710	0·68	16·20	594,252·36	172	(*d*)	(*d*)	30·34	0·04	23·79	17·90	2·41	—1·70	—0·27
1901 ..	2,300,000	313,562	3,757,419	0·83	16 09	628,045·94	123	(*d*)	24·75	25·75	1·00	16·42	15·22	2·59	0·77	0·12
1902 ..	2,300,000	315,657	5,259,140	0·83	11·88	632,717·37	127·2	(*d*)	7·23	28·81	1·31	24·34	11·42	1·89	0·46	0·08

ISLE ROYALE MINE.

1901 ..	2,000,000	185,175	2,171,955	0·585	(*d*)	281,269	120·0	5·50	3·90	24·91	(*d*)	32·00	32·57	1·86	(*d*)	(*d*)
1902 ..	2,000,000	263,672	3,569,748	0·675	11·91	500,775	98·8	5·07	2·35	26·43	7·1	19·30	13·45	1·59	—1·54	—0·29

OSCEOLA MINE.

1898 ..	2,295,000	505,008	11,800,000	1·168	(*d*)	1,549,890·12	(*d*)	(*d*)	(*d*)	28·94	18·10	(*d*)	9·98	2·33	3·15	0·74
1899 ..	2,328,750	546,326	10,950,000	1·002	(*d*)	1,791,471·01	(*d*)	(*d*)	(*d*)	26·30	13·29	(*d*)	11·48	2·30	4·92	0·98
1900 ..	2,397,500	662,046	11,200,000	0·819	(*d*)	2,136,953·02	(*d*)	(*d*)	(*d*)	27·20	27·68	(*d*)	13·92	2·28	5·15	0·85
1901 ..	2,397,500	798,207	13,723,571	0·865	13·90	1,934,437·14	157·0	(*d*)	(*d*)	26·575	60·95	(*d*)	14·64	2·53	0·005	0·09
1902 ..	2,408,750	836,400	13,416,396	0·808	11·78	1,594,453·76	137·0	(*d*)	(*d*)	21·735	10·20	(*d*)	10·55	1·79	0·007	0·12

QUINCY MINE.

							(*e*)	(*f*)							(*i*)	(*i*)
1898 ..	1,450,000	543,532	16,354,061	1·54	12·14	1,986,116·81	165	(*d*)	(*d*)	(*h*)22·28	39·59	34·23	8·17	2·39	3·97	1·16
1899 ..	1,450,000	559,164	14,801,182	1·27	17·13	2,450,178·66	181	(*d*)	(*d*)	(*h*)22·19	72·39	27·50	10·96	2·81	6·17	1·58
1900 ..	1,450,000	558,723	14,116,551	1·26	16·67	2,353,416·59	208	(*d*)	(*d*)	(*d*)	108·3	28·17	13·68	3·44	3·04	0·77
1901 ..	1,450,000	686,266	20,540,720	1·19	16·02	3,399,574·80	181	(*d*)	(*d*)	(*d*)	18·87	23·28	9·61	2·23	6·94	1·61
1902 ..	1,450,000	953,019	18,988,491	0·99	11·99	2,275,819·25	155	(*d*)	(*d*)	(*d*)	10·09	19·50	9·02	1.79	2·97	0·59

TAMARACK MINES.

1898 ..	1,500,000	670,832	22,500,000	(*d*)	(*d*)	2,881,866·95	179	(*d*)	(*d*)	22·40	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)
1899 ..	1,500,000	631,090	17,750,000	1·40	(*d*)	2,952,098·91	(*d*)	(*d*)	(*d*)	22·73	63·49	(*d*)	12·46	3·50	4·17	1·17
1900 ..	1,500,000	695,422	18,400,000	1·47	(*d*)	3,299,077·26	(*d*)	(*d*)	(*d*)	31·48	(*d*)	(*d*)	11·41	3·36	6·52	1·92
1901 ..	1,500,000	636,905	18,000,852	1·43	14·22	2,627,954·35	244·0	(*d*)	(*d*)	24·95	44·87	(*d*)	11·67	3·35	(*l*)4·48	(*l*)1·28
1902 ..	1,500,000	658,730	15,961,898	1·21	11 87	1,941,907·26	280·0	7·28	(*d*)	23·30	23·50	23·65	11·90	2 88	(*l*)1·24	(*l*)0·30

WOLVERINE MINE.

(*g*)							(*a*)									
1898 ..	600,000	180,089	3,470,927	1·33	11·43	399,368·77	119	(*d*)	23·51	36·63	47·42	33·33	9·73	2·60	1·70	0·45
1899 ..	600,000	184,799	4,700,373	1·27	14·35	675,859·08	100	(*d*)	19·66	36·68	5·83	34·00	7·71	1·96	6·64	1·69
1900 ..	600,000	184,594	4,756,646	1·29	16·86	806,810·32	112	(*d*)	24·01	41·19	36·67	32·34	9·67	2·46	7·20	1·85
1901 ..	600,000	190,104	4,907,646	1·29	16·74	828,797·32	116	5·94	24·16	36·89	14·56	30·00	8·84	2·28	7·90	2·04
1902 ..	600,000	187,482	4,964,367	1·33	13·21	665,333·28	133·3	5·88	20·70.	34·36	141·18	32·13	13·82	3·67	—0·61	0·13

(*a*) Sales of copper and interest. (*b*) Includes underground and surface expenses and costs of stamping. (*e*) Includes transportation to mill and surface expenses. (*d*) Not stated in the reports. (*e*) Not including interest. (*f*) Includes mining, transportation to mill, surface and stamping costs. (*g*) Fiscal year ending June 30. (*h*) Included under mining costs. (*i*) Exclusive of interest and income from real estate. (*k*) Not including assessments. (*l*) Not deducting extraordinary construction account from annual profits. (*m*) Not including taxes.

The Calumet & Hecla Mining Co. during 1902 continued making additions and improvements to its equipment, and this work will be carried on for some time to come. The Red Jacket shaft, which is bottomed in the conglomerate at a depth of 4,920 ft., is supplied with hoisting engines aggregating 8,000 H.P., and capable of raising over 2,000 tons of ore daily. A duplex air compressor with a capacity of 550 drills is to be installed. Shaft No. 4 has been carried to a depth of 6,900 ft. on the incline. The amygdaloid ore body was not worked, owing, it is said, to the low price of copper. Explorations from the Red Jacket shaft show that the conglomerate gradually decreases in copper tenor with depth. The electrolytic plant at Black Rock on the Niagara River was started during the year. The Osceola Consolidated Mining Co. has practically abandoned work at the Tamarack Junior mine, and hereafter will confine its operations to the Osceola, North Kearsarge, and South Kearsarge mines. The Osceola No. 5 shaft was idle for a large part of the year owing to a cave-in, which badly damaged the shaft timbers. A large amount of development work was done in the North Kearsarge and South Kearsarge mines, and extensive ore reserves have been made available. The Quincy Mining Co. completed the construction of the new coal dock and coal hoisting plant which will effect a considerable saving in the cost of fuel. A new warehouse for the storage of refined copper was erected at the smelting works. At the Tamarack mine the new No. 5 shaft, which is 4,938 ft. in depth, was operated for the first time in December, 1902. Seven levels have been opened from the shaft giving facilities for a large daily output of ore. Operations last year were restricted to some extent owing to the low prices of copper. The Wolverine Copper Mining Co. started its new mill on Traverse Bay in August. The mill has two steam stamps capable of handling daily about 1,000 tons of ore, or double the capacity of the old mill. This company produces copper at a very low cost so that it was able to maintain the regular dividend payments throughout 1902. The year's developments at the Baltic mine were highly satisfactory, the output of fine copper being more than double that for 1901. The new mill at Redridge was placed in commission, but was operated only at partial capacity, as two of the stamps were not ready until late in the year. When the four stamps are in operation the Baltic will rank well up in the list of Michigan mines. The Isle Royale Copper Co. started work in its new 3-stamp mill on Portage Lake, but one stamp only was operated during the latter half of the year in order to make possible a closer selection of ore. The Isle Royale and Portage lodes have proven to be "bunchy," and their successful exploitation requires large ore reserves with close selection of ground in accordance with the prices obtainable for copper. The Adventure Consolidated Copper Co. during 1902 received $70,791 from the sales of copper and $1,182 from the sales of silver, while the total income, including an assessment of $200,000, was $278,714. The total expenditures for mining and additions and improvements to the company's property amounted to $718,805, leaving a balance with that brought forward from the previous year of $69,571. Owing to delay in the equipment of the stamp mill the production of copper was much less than expected. The Mohawk Mining Co. in the past year received $104,417 from the sales of mohawkite and metallic copper, and $340,249 from assessments

can show as good, if not a better economic record for the year. The matte produced by the Colorado smelter and the Butte Reduction Works is being converted at the New Washoe plant. In August a fire destroyed the reverberatory department of the Butte Reduction works, but it was rebuilt and again in operation in October. The fire did not necessitate the closing of the other departments of the works. The smelter owned by the Montana Ore Purchasing Co. continued in active operation, although a fire on August 28 completely destroyed the company's concentrator, which was the means of curtailing the output of the smelter itself. The concentrator was not rebuilt, but instead the management leased the uncompleted concentrator at Basin owned by the Basin & Bay State Mining Co. This plant has been put in working order, the Montana Ore Purchasing Co. sending its crude ore to Basin, and returning the concentrates to the smelter at Butte to be treated. During the year Mr. Heinze merged the Montana Ore Purchasing Co. and auxiliary companies into the United Copper Co., with an authorized capital of $80,000,000 divided into 50,000 common shares, all of $100 par value. Of the common stock 300,000 shares have been reserved in the treasury. Early in the summer the Speculator mine was closed by a court injunction, and remained idle during the remainder of the year. The Minnie Healey mine, which was operated by Mr. Heinze, was also closed by an injunction. The Pittsburg & Montana Copper Co., which succeeded the Farrel Copper Co., prosecuted development work by sinking two shafts to bedrock on the flat east of Meaderville. The completion of this work has been attended by unexpected difficulties. The depth to solid formation was found to be in the neighborhood of 700 ft., a goodly portion of the sinking being through quicksand. The net earnings of the principal copper mining companies during the fiscal year ending June 30, 1902, as reported to the assessor of Silver Bow County, were: Anaconda Copper Mining Co., $1,289,610; Boston & Montana Consolidated C. & S. Mining Co., $1,639,695; Montana Ore Purchasing Co., $600,000; Butte & Boston C. & S. Mining Co., $166,136; Colorado Smelting & Mining Co., $152,495; Parrot Silver & Copper Co., $577,617; Colusa-Parrot Mining & Smelting Co., $397,475. Outside of Butte the copper properties have not yet reached the productive stage. The Indian Queen, near Dillon, has shown large bodies of glance and chalcopyrite, but it is not yet a regular producer. The Basin Creek properties, in Jefferson County, have been worked throughout the year, and development work has been carried on in the copper properties near Helmville. The Sweet Grass Hills and Blackfoot Reserve properties are as yet in the prospect stage.

Nevada.—The property of the New York & Nevada Copper Co., in White Pine County, was actively developed, and construction work was begun on a 500-ton concentrator and smelting plant near Ely. The ore is chalcopyrite and chalcocite in a gangue of quartz porphyry and averages about 3% Cu. A tramway will be built to connect the mine and smelter. The Nevada Copper Co. and the Bell Mare Mining & Smelting Co., both operating in the Table Mountain district, were consolidated under the name of the Bell Mining & Reduction Co., which plans extensive developments.

New Jersey.—The reduction plant of the Arlington Copper Co., Ltd., erected

[illegible] was inactive during 1902, except for experimental runs.

[illegible] The Burro Mountain, San Andreas, Lordsburg and Black Range districts made good progress during 1902, and an increased output of ore was recorded in each of these mining centers. The Burro Mountain district is located in Grant County about 15 miles southwest of Silver City. Mines were conducted in the district on a small scale since 1875, but it is the last three years that the operations have assumed any marked importance. The main copper bearing area is about three miles long and two miles wide, with a general east and west strike. The prevailing rocks are granite porphyries which by metamorphism and disturbance, have been thoroughly altered and the veins mineralized with iron, manganese and copper oxides. Even the country rock contains impregnations of malachite and azurite [illegible] low grade ore bodies. The low-grade ore is to be treated by [illegible] sulphuric acid, for which a sufficient supply of water can be obtained from the deeper workings. New discoveries of copper ore were reported [illegible] and Organ Mountains and in the Sacramentos.

[illegible] At the Gold Hill mine in Rowan County a 20-stamp mill [illegible] copper gold ores. The Union Copper Co. is reported to have disclosed large bodies of ore in the Randolph shaft, which assays about 10% Cu. A [illegible] and a leaching process are to be installed at the Rowan mine.

[illegible] A small copper smelter is in course of erection near Hill. The [illegible] Black Hills Copper Co., which exploits a deposit of copper [illegible] has erected a leaching plant with crushers and six leaching tanks, [illegible] precipitate copper.

[illegible] The [illegible] copper [illegible] in the Rowan district were [illegible] The [illegible] [illegible] leaching plant [illegible] [illegible] the two furnaces were [illegible] [illegible] in the [illegible] The quantity of ore treated was [illegible] [illegible] [illegible]

net profits after providing for interest on debentures and appropriating £3,000 to depreciation amounted to £14,761. An interim dividend of 5% was paid, and a further dividend of 5% on the ordinary shares and £9 18s. per share on the founders' shares was declared.

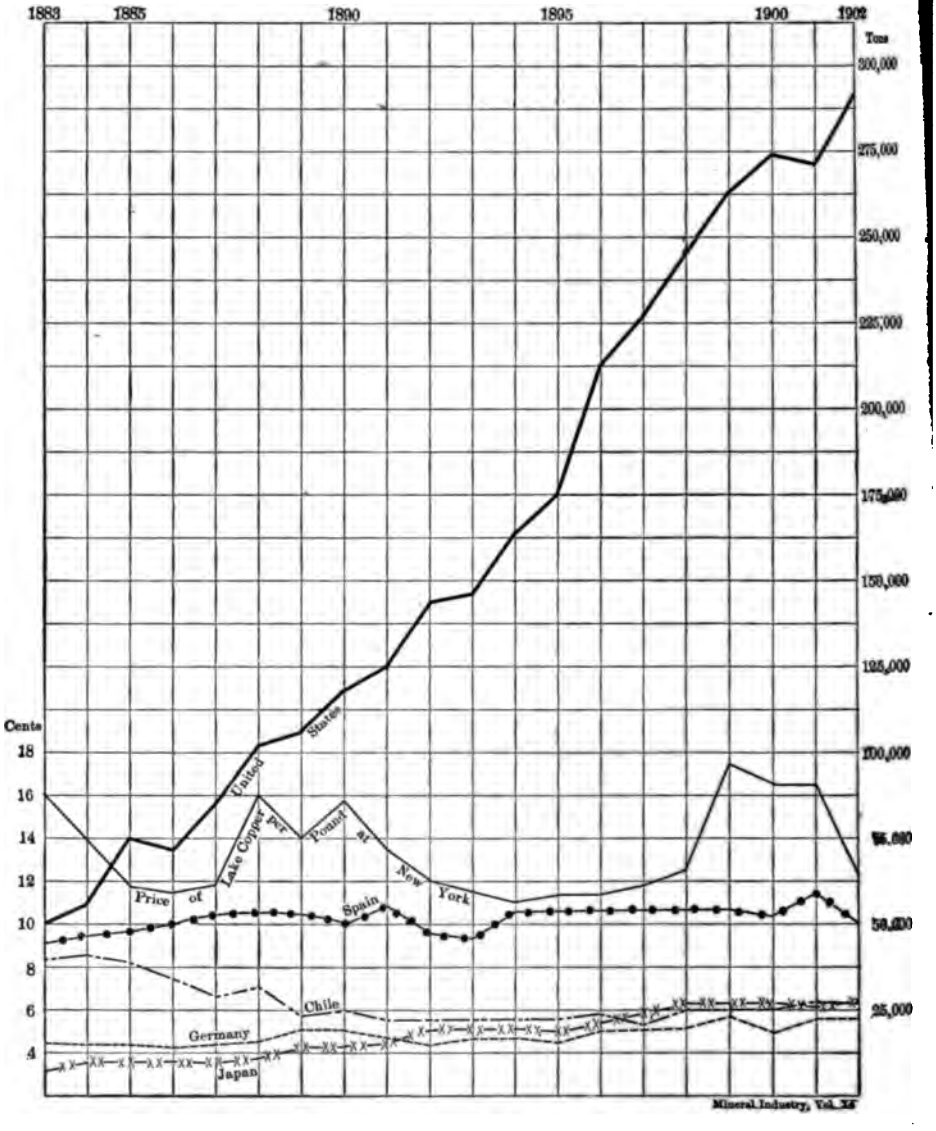
Utah.—The Bingham district formerly a producer of low-grade silver-lead ores is now the largest copper mining camp in the State. The Highland Boy shipped about 500 tons of ore per day, which were treated in its own furnaces. New developments in the mine have exposed large ore bodies in the limestones above the old workings so that the future of this company appears promising. The Bingham Consolidated mines produced about 250 tons of fluxing ore daily, which together with siliceous ores purchased in the open market was handled in the company's smelter. The United States Mining Co. has erected a complete smelting plant with three furnaces, and during the year treated daily about 300 tons of ore from Bingham mines mixed with siliceous ore from the Centennial mine at Tintic. This plant reduces the ore in a blast furnace without previous roasting, and produces converter matte with two smeltings. The company has large ore reserves, and will increase the output of copper during 1903. Work has been prosecuted on a number of other properties in the Bingham district with the result that two mines—the Boston Consolidated and the Yampa—have been brought to the productive stage warranting the erection of smelters. The Columbia Copper Co. operating in the main Bingham Cañon has steadily developed its mine, shipping the ore in the form of concentrates.

Wyoming.—(By Wilbur C. Knight.)—The progress in the copper mining industry has been of development rather than production, the greatest changes having been made in the Grand Encampment and the New Rambler camps. The North American Copper Co. purchased the Ferris-Haggerty mine, the new tramway that has been put in at a cost of over $250,000 to connect the mine with the smelter, the Grand Encampment smelter, and numerous other valuable rights. The purchase price was stated to be $1,000,000. The company has commenced extensive development at the mine, and is erecting a large concentrating plant. It is claimed that the Union Pacific Railroad will construct a branch into the camp. Other properties have been greatly developed during the year; to the southward the Pearl district has been opened up on the Colorado-Wyoming line. In the New Rambler district, early in the season, a new matting furnace was installed, which made several very successful runs. Later, an Eastern company purchased the Rambler mine and incorporated it for $2,000,000. The Laramie & Hahns Peak Railroad, now under construction, which is graded to a distance of about 25 miles southwest of Laramie, will pass within a few miles of this property. Several companies have opened very promising prospects near the New Rambler. The discovery of platinum and palladium in the Rambler vein was of more than ordinary interest, and, as far as is known, this property is the only producer of ore carrying these rare metals. From an average of many assays the covellite ore contains 3·5 oz. of platinum and palladium to the ton, sometimes being all palladium. Although about 2,000 tons of this ore was sold, nothing was paid for the precious metals contained. At Hartville, an old-time copper camp, some very rich ore bodies have been discovered.

pper Islands.—Copper deposits of considerable importance are found
land of Mindanao, in the region inhabited by the Moros. The na-
s and on the Chinese, have exploited the ores on a small scale with re-
ome results. The ore obtained from small workings is pounded on
ated pieces of metal, and the crushed material is then run through
These mills are of stone or iron, and are turned by hand or by a water
In some places there are large furnaces for heating the rock, prepara-
crushing, and several smelting furnaces have been in operation, some
erated by Germans. The native miners are said to be efficient work-
of iron to be obtained for a few cents a day. Gold and silver as well as
are found in Mindanao.
recent enactment of Congress, the mineral deposits of the Philippines
Chinese open to exploration and purchase by citizens of the United
tates of the Philippines and Spaniards in the Philippines who have
their intention of becoming citizens of the Islands. Claims for lode
are limited for each individual to 1,000 ft. square; for placer mining
ims, and for coal lands to 160 acres. Provision has been made for
inspection and registration of the claims upon proof and payment of the
required, and the publication of notice in two newspapers of the Islands.
Annual assessment of work must be done upon the claims each year in order
them.

Copper Mining in Foreign Countries.

Australia.—Both the depressed condition of the copper market and the severe



The Production of Copper in the Principal Countries of the World. (In Metric Tons.)

drought had an unfavorable influence upon mining operations, which under more normal conditions would have shown a greater expansion.

of these companies, as well as of those in Rossland, were hampered seriously by strikes at the coal mines upon which they depend for cheap coke supplies, and the copper output was therefore much less than it would have been under more favorable conditions. The copper deposits in the Boundary district are usually of large size and of self-fluxing composition, and although yielding extremely low values they can, with possibly one or two exceptions, be worked at a profit. The Granby Co. is engaged in the construction of two new furnaces which will bring its capacity up to about 2,100 tons daily. The plant is equipped with converters and handles the matte of the two other smelters, so that the entire shipment from the Boundary district is in the form of metal. Mining and smelting operations in this vicinity are greatly facilitated by the supply of electric current from the power plant at Cascade, B. C. From the generating station lines extend to the Granby smelter and to Phœnix, a distance of 22 miles. The Hall Mining & Smelting Co. in the Nelson district, during the year ending June 30, 1902, mined and treated 22,661 tons of ore for a yield of £66,179. The copper furnace treated 22,936 tons of ore from the Silver King mine and 2,558 tons purchased from other mines. The results of operations in all departments show a net loss for the year of £5,946. In the Coast districts much activity was manifested during the year, smelting facilities being provided by the Northwestern Smelting & Refining Co., at Crofton, V. I., and others. Unfortunately one of the largest mines became legally involved, and on this account the copper output from the Coast mines was 310 tons less than in 1901. This part of the Province appears to have a particularly bright future, due to its many good copper prospects.

The output of copper-nickel ore in Ontario in 1902 was 265,538 tons, of which 233,388 tons were smelted yielding 38,023 tons of matte. The copper content of the matte was 4,066 tons, valued at $616,763.

Copper mining has been carried on as usual at Capelton by the Nichols & Eustis companies, with an output of 32,938 tons, valued at the mine at $121,170. A quantity of 12,152 tons has been shipped to the United States, while the balance remains in Canada for use at the chemical works of Capelton. The Ascot mine has been worked during the year for development purposes, with a small output of good grade ore. The King & Norton's mines have also been a little developed, and the old Ballarat mine, in Melbourne, has been pumped out for examination purposes. During the year, there was talk of establishing a custom smelter in Sherbrooke or its vicinity, and if a sufficient supply of ore could be obtained to support it several old mines would be re-opened and new ones started, having then a ready market for their output, big or small. The district around Sherbrooke is rich enough in copper ore to encourage such an enterprise. A new discovery of high-grade copper ore has been made near Matane, in the county of this name. The ore found is mostly bornite with some chalcopyrite. Native copper is also found in small quantity. A local company is presently sinking down with a small steam plan, and it claims to be satisfied with the results.

Cuba.—There have been no notable developments in copper mining during

mines, Durango; Dolores in Matehuala; Santa Fe Chapas; Bolaños; Barranca de Cobre, etc.

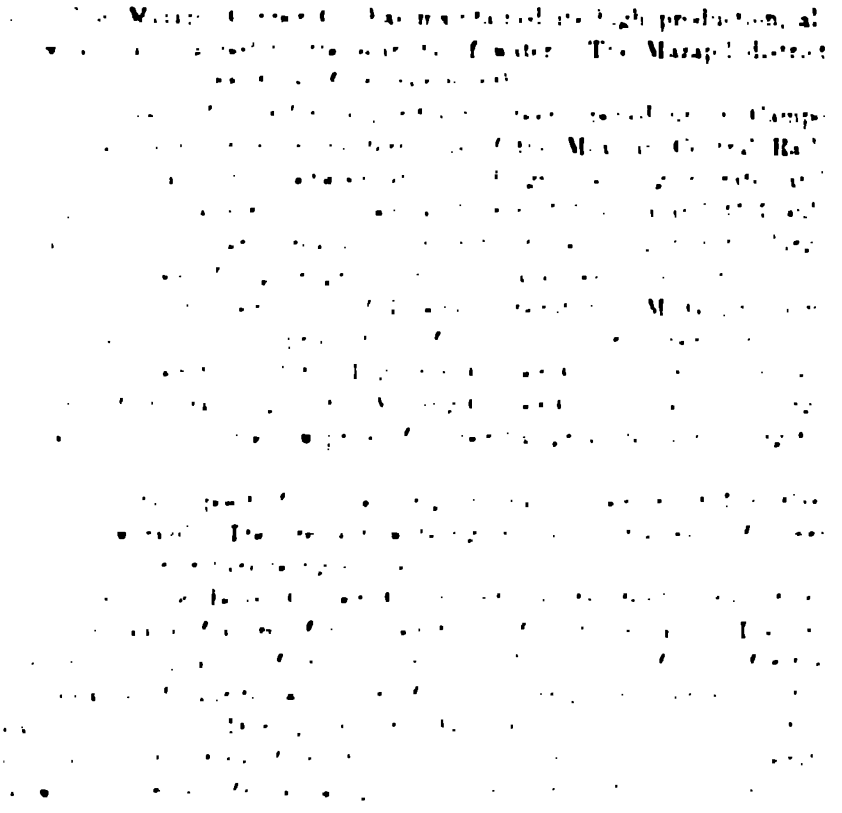
Sonora.—The completion of the Nacosari and Cananea copper smelting plants, the building of two smelters—the Copper Queen, and the Calumet & Arizona—at Douglas, Arizona, on the northern frontier, mark a new era in the history of mining in the State of Sonora. At least one of these smelters will be a custom smelter and will purchase gold and silver ores in addition to those of copper. The extension of railroads from these smelters into the heretofore undeveloped mining camps in the southeastern part of Sonora is now within measurable distance.

The Greene Consolidated mines at La Cananea now produce daily approximately 1,000 tons of ore, assaying 7% Cu. The ore reserves opened up by exploration work during 1902 have been phenomenal, and there is more ore in sight at present than at any previous time, although extraction has been maintained at a high level throughout the year. The Cananea ore occurs as bonanzas, the ore bodies being an alteration of limestone and quartzite and as a general rule carrying an excess of silica. Some of the ore bodies, especially in the Oversight mine, are exceptionally rich, assaying in large lots 25% Cu. A concentrator has just been installed with four jigs and 52 Wilfley tables capable of handling daily 600 tons of ore, which will produce 200 tons of concentrates. According to the official report of this company the production during the fiscal year ending July 31, 1902, was 26,665 short tons of copper matte, which contained 23,991,617 lb. copper and 194,609 oz. silver, and 3,862,880 lb. copper bullion containing 39,120 oz. silver and 342 oz. gold. The ore smelted comprised 142,968 tons copper ore and 52,855 tons iron ore, and the average yield was 9·8% Cu and 1·7 oz. silver per ton. The income for the year was $802,833, out of which $200,000 were paid in dividends, and $417,671 set aside for depreciation and legal requirements.

At the Moctezuma copper mine at Nacosari, 60 miles southeast of La Cananea, the ore is a mass of crushed porphyry on a fault plane, the interstices of which have been filled with copper and iron pyrites. All the ore is concentrated by jigs, the jig tailings being re-crushed and passed over Frue vanners. A concentration of 3 to 1 is effected. The sulphide concentrates are smelted without roasting and the resulting matte is Bessemerized in a converter having a very thick lining of low-grade gold-silver quartz mined from an adjacent property of the company. The Loomis-Pettibone fuel gas installation at this plant has given great satisfaction, the consumption of fuel being under 3 lb. of inferior cordwood per H.P. per hour. The Santo Niño copper mines near the Yaqui River, east of Minas Prietas, have received some attention during 1902, but their importance as producers of copper has probably been exaggerated.

Chihuahua.—On account of the decline in the price of copper, the mines and smelter of the Rio Tinto Mexicana Co. at Terrazas, have suspended operations, and work at the Magistral mines, west of the city of Chihuahua, has been carried forward on a very limited scale.

Durango.—Very large quantities of basic silver-copper ores have been opened up in the Descubridora copper mines, near Conejos, and the construction of the



all exported, 35,947 tons going to Great Britain and 35,538 tons to the United States. The ore is smelted at the works of the Nichols Chemical Co., in the United States, and at those of the Cape Copper Co., in England. The report of the Cape Copper Co., Ltd., for the fiscal year ending Aug. 31, 1902, shows an income from operations at Tilt Cove of £75,176, and a net profit of £11,748. During the year the East mine produced 49,147 tons of ore, averaging 3·20% Cu, the South lode 9,417 tons, averaging 3·85% Cu, the North lode 7,119 tons, averaging 3·32% Cu, and the West mine 1,896 tons. Of the output, 23,388 tons were shipped to Swansea, Wales, 38,578 tons to New York, and 8,319 tons to Garston. The York Harbor property was sold in December, 1902, to an American company for $400,000.

Norway.—The Sulitjelma mine, according to reports, produced about 66,000 tons of copper ore and pyrite in 1902, and the Röros mine about 25,000 tons. The ore from these mines, averaging from 5 to 6% copper after roasting, is smelted in American water-jacket furnaces to matte carrying about 40% copper, and the latter is then treated by the converter process. The total cost of producing fine copper is about 6·8c. per pound. The sale of the Skjangli properties to American capitalists was reported. These properties are situated in the northern part of the Scandinavian peninsula on both sides of the Norway-Sweden boundary line, and contain low grade ore carrying small quantities of gold and silver. The properties are as yet undeveloped.

Portugal.—The report of Mason & Barry, Ltd., for the year 1902, states that the quantity of ore raised was 177,563 tons, while the shipments amounted to 405,111 tons. The net profits on working account were £90,495; the stocks of ore and copper precipitate at the close of the year were valued at £90,495.

Russia.—This country consumes annually about 22,000 tons copper, 14,000 tons being imported. About 90% of the domestic production was furnished by the Ural and Caucasus districts. Since the Trans-Siberian Railroad has been completed, the copper deposits of the district of Krasnojarsk in Central Siberia have been opened. A Russian-English corporation has been formed, which is reported to have received a concession from the Russian Government for the exploitation of an area of 1,200 acres, 110 miles from the Yenisei River and directly connected with the Trans-Siberian Railroad.

South Africa.—The report of the Cape Copper Co., Ltd., for the year ending April 30, 1902, for South Africa, and August 31, 1902, for London, shows a loss in the year's operations of £6,494, which with the balance brought forward from the previous year left a credit of £158,194. Out of this sum a dividend of £138,000 was paid, and the balance, after deducting income tax of £5,605, was carried forward to 1903. At Ookiep 14,691 tons of ore were smelted and at Nababiep 10,717 tons. Operations were hampered by incursions of the Boers, who inflicted much damage upon the mining and smelting machinery. The British South African Co. has granted mining concessions aggregating 560 square miles in northern Rhodesia to the Northern Copper Co., who in turn have conceded 500 square miles to the Rhodesia Copper Co. The area covered by these grants has been partially explored with the result that many promising prospects have been located, some of which bear evidence of having been worked in ancient times

THE COPPER MARKETS IN 1902.

New York.—The course of the market during 1902 was very interesting in a good many respects and was again followed with marked attention on the part of those directly and indirectly connected with the industry, as well as by the general public. In view of the erratic policy pursued by one of the largest factors in forcing the output of its mines after having accumulated large stocks, and in selling its copper in a manner surprising and inexplicable to the more conservative business men in the trade, the impression gained firm footing that the policy inaugurated in December, 1901, was to be continued indefinitely, that is, to bring the price down to a very low level and keep it there at all hazards. There was comparatively slight resistance to this movement from Europe, where business throughout 1901 was rather disappointing, and traders there took full advantage of this carefully nursed specter, depressing prices long before our manufacturers awoke to the fact that a further heavy decline was imminent. However, the course of events made it apparent to the more experienced authorities in the trade on this side that in view of the very large consumption in the United States, the popular estimates of the available supplies were wildly inaccurate, all signs pointing to a rapid decline of the stocks on hand. It is true, production showed an increase, in spite of the prevailing low prices. A number of new mines have started active operation. On the other hand, all the copper consuming industries have been exceedingly busy throughout the year. The brass as well as sheet mills have taken heavy quantities of copper. The railroads had to replenish their rolling stock, which was acknowledged to be inadequate. The shipbuilding industry was very prosperous, and last but not least, enormous quantities have been sold for electrical purposes. The use of copper for traction purposes seems to have only just started, to say nothing of local extensions of electrical lines that are being, both in America and Europe, extended to longer distances and made to connect cities as well as points within cities. This is evidently only a forecast of the use of electricity for long distance travel, and experiments in that direction are continually being made on both sides of the Atlantic. At the beginning of the year the greatest uncertainty prevailed in the copper market, and it was evident that the retrograde movement which had commenced in November, 1901, had not yet terminated. Prices opened nominally for Lake at 12c., electrolytic at 11·75c., but very soon a further cut of 1c. was made, followed by quite large sales at the parity of 10·875c. and 10·625c., respectively, at which figures consumers at last operated freely, and speculators were not slow to take an interest in the markets, trying to contract for whatever they could lay their hands on. This enormous buying sufficed to put an end to the forced depression in prices which had been systematically worked for the two previous months, and the moment it was felt that prices had about reached bottom, consumers who had allowed their supplies to drop to the lowest ebb, purchased very largely, not only for prompt delivery, but also as far ahead as they possibly could. The interests which had been instrumental in forcing prices down were evidently unable to withstand the flood of orders pouring in from all sides. Quotations advanced quickly to 12·5c. for Lake and 12·25c. for electrolytic, ruling at these

showed renewed strength, rallying to £55 10s. spot and £56 three months; at this point some European companies made large sales of tough copper at £60.

Early in March the market was weaker, declining to £52 2s. 6d. for spot, with a backwardation of 5s. on futures, but some large purchases made by the British Government rather improved matters. Consumers also made some heavy purchases on the lower prices. The feature of the situation about this time was the large shipment of electrolytic copper from America made by the Amalgamated Co., in consequence of which the price of refined fell off, sales of that variety being made at very little above the quotation for standard.

In April there was a considerable speculative movement for the advance, which, however, failed in its object, owing to continued heavy offers from America. The market at this time, as well as earlier, was considerably puzzled by the tactics of the American producers, whose main object seemed to be to keep prices at the lowest possible level. In May there was a better demand from consumers, who generally required prompt delivery, showing that their needs were urgent. In June the conclusion of peace in the Transvaal was used as a bull point, but produced little effect, and later this was neutralized by the unfavorable influence of the King's illness. A considerable trade for the Continent sprung up, however, and large orders were placed for electrical work, buyers being tempted by the narrow margin between standard and electrolytic.

In July, heavy offers from the United States continued, and consumers were inclined to hold off, the reports from abroad indicating a further possible fall. The month closed with standard selling at £53 for spot and £53 5s. for three months. In August a temporary rise, caused by short covering, was neutralized by further reductions offered from New York, and prices slipped back to £51 5s. spot and £51 10s. for three months. The European producers were apparently tired of waiting, and offered metal much more freely than in the early part of the year. September opened uncertain, owing to the contradictory rumors as to Amalgamated policy, but some strength was lent to the market by the statement of stocks prepared by Dr. Ledoux and printed in the *Engineering and Mining Journal*. Contradictory rumors prevailed, however, but they did not prevent consumers from making extensive purchases. At the close of the month, however, it was found that manufacturers were generally stocked, and copper closed rather flat at about £51 15s. spot and £52, three months.

Many people looked for some recovery in October, but the heavy bear operation in Rio Tinto shares, which was engineered from Berlin, had an unfavorable effect on the metal market, and prices declined to £51 10s. for spot. At this level a considerable demand from consumers, whose stocks were again exhausted, improved the tone, and there was a hardening to between £52 and £53. November opened with the visible supplies reduced to the low figure of 16,657 tons. There was also a fair consumptive demand. Rumors from America of an increase in stocks received some belief, however, while the unfavorable condition of the stock markets and the unsatisfactory position of affairs in South Africa also affected trade, and the market closed flat at £49 12s. 6d. for spot, with about 5s. better for forward copper. The only support to the market at this time was from the copper sulphate trade, makers of that article purchasing rather heavily

[illegible] These had the effect of improving the prices of tough and best [illegible]

[illegible] was a result of some excitement, prices opening flat, but early in [illegible] reported rumors of a working arrangement among American producers [illegible] about a sharp advance of over £2. The break of the operation for the [illegible] market by a very sharp advance in these shares, also helped [illegible] Unexpected assistance was derived from free purchases made by [illegible] of the syndicate. The year closed with a firm tendency, standard being [illegible] £[illegible] to £[illegible] 10s. cash for spot, with some 10s higher named for [illegible]

[illegible] of the market which was noted throughout the year was the persistency [illegible] of sales in pressing interests. It has happened very seldom [illegible] that these stocks directly against their own apparent advantage. The London market was for the most part thoroughly at ease as to [illegible] of stocks in consumers' movement. It is also to be noted that Germany was a [illegible] throughout the year owing to continued depression in manufacturing [illegible] where a brisker trade was nearly stationary at a dull level throughout.

[illegible] PRICES OF STANDARD COPPER (£ M.R.'s) IN LONDON

[illegible] sterling per long ton of 2,240 lbs.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Progress in the Metallurgy of Copper during 1902.

By Joseph Struthers and D. H. Newland.

The following notes on the progress in the metallurgy of copper during 1902 have been abstracted chiefly from the technical literature of the year, in addition to information and criticism which have been obtained by direct correspondence or discussion with practical metallurgists.

Automatic Ore Sampling.—An illustrated description of automatic system of sampling at the smelter of the British Columbia Copper Co., at Greenwood, B. C., will be found in the "Review of the Progress in Ore Dressing during 1902," given elsewhere in this volume. The results of practice at this plant are fully discussed in The Mineral Industry, Vol. X., pp. 206-211.

Smelting Ore and Matte at Leadville and Robinson, Colo.[1]—The following data of furnace working at the Bi-metallic plant, Leadville, and at the plant of the Robinson Construction, Mining & Smelting Co., Robinson, have been prepared by Mr. C. H. Doolittle, referring to practice during the year 1900. At Leadville, the Bi-metallic plant was equipped with three furnaces having cross sectional areas at the tuyeres of 36×163 in., 36×176 in., and 36×215 in., respectively. The two smaller furnaces were used for concentrating the ore into a low-grade matte, and the largest one for concentrating the low-grade matte with the addition of oxidized siliceous ores to matte of a high-grade. Cold air was furnished by three No. 7 Root blowers, so connected to the furnaces that each furnace could have its individual blower, an arrangement which was found preferable. Two fans, one 9 ft., and one 6 ft. in diameter, were connected with the dust chamber, and the gases, after having traveled a distance of 300 ft., were forced through towers in which a water spray precipitated a large part of the fume, rich in lead and silver. The gases escaping from the towers were damp and were reduced to a temperature of 100° F., finally passing into the atmosphere through a wooden stack. The power was furnished by a 450-H.P. Corliss engine. The furnaces were operated so that the matte produced by the ore furnaces was just sufficient for the reconcentration furnace, and the slag from the reconcentration furnace, which had to be re-smelted, was not too burdensome for the ore furnaces, but still sufficient to keep an open charge in the ore furnaces. In this manner, the locking up of capital in large surpluses of low-grade matte and rich slag was avoided.

The analyses of the characteristic ores treated are given in the subjoined table:

Name of Mine.	Components of Ore.				
	SiO_2.	Fe.	CaO.	Zn.	Cu.
	%	%	%	%	%
Iron Silver	3	41	0	6	0·1
Ibex M. Co	20	28	0	6	2·7
New Monarch	28	18	0	11	3·5
Marian	8	38	0	1	0·5
Minnie	23	28	0	9	3·0
Commodore	85	3	2	0	0·0
Centennial-Eureka	77	5	2	2	6·0

During March, 1900, the three furnaces were in continuous operation and treated 9,838 tons of ore containing Au 2,256 oz., Ag 159,811 oz., and Cu

[1] *Engineering and Mining Journal*, April 11, 1903.

	Tons.
Washington mine ore	7·60
Robinson mine ore	81·00
Wintergreen mine ore	36·98
Total ore	125·58
Lime rock	25·65
Slag	55·50
Total charge	206·73
Coke	16·50
Percent fuel on ore.	13·14

Slag assay and analysis were:

SiO_2	41·0%
FeO	30·8%
MnO	5·5%
CaO	17·0%
ZnO	4·0%
Ag	1·1 oz.
Total	98·3%

Analysis of re-smelting matte:

Ag	42·07 oz.
Cu	0·2%

A 24-hour run on reconcentration matte was:

	Tons.
Robinson mine ore	116·50
Pride mine ore	28·42
Total ore	144·92
Matte	121·58
Lime rock	21·90
Total charge	288·34
Coke	14·60
Percent fuel on ore	10·00

Analysis of matte:

Ag	200 oz.
Au	0·5 oz.
Cu	50·0%

The average fuel consumed during the time the smelter was in operation was 13·5%, being about 1% less than the fuel consumption at Leadville. After smelting 3,289 tons of ore the works were shut down. The quantity of flue dust produced was 2·5% of the ore treated. The cost of fuel and labor was $2 per ton of ore. Labor in this case does not include management, superintendence, etc.

The capacity of the ore furnace was 75 tons per day. The slag averaged SiO_2 36%, Fe 36%, CaO 7% and Zn 5%. A saving might have been made by the addition of a larger proportion of lime and less iron, but from a commercial standpoint, a $9 rate on a neutral basis on iron ore allowed a fair margin for the treatment of that class of ore. The average cost for the month showed $3·645 per ton of ore treated, including all expenses except new construction. The matte was shipped to the Philadelphia Smelting & Refining Co. at Pueblo and treated for $3·25 (freight and treatment), allowing $19·25 per oz. for gold, 95% of the silver, and 4c. off casting brand quotation for copper.

The Robinson Construction, Mining & Smelting Co. was equipped with one stack having a cross sectional area of 36×142 in. at the level of the tuyeres. A Loder hot blast apparatus was attached to the furnace consisting of a series of pipes carrying the air in a chamber through which the gases escaping from the furnace pass on their way to the dust chamber. The highest temperature of blast obtained was 200°F.

To the copper metallurgist the results shown by the data given above will undoubtedly seem small in tonnage, but the ores are similar to those handled

The matte produced is represented by 396 hourly samples. Ignoring fra tions, the variations in assays ranged from 11 to 32% Cu, averaging numerically for all the samples 21·18% Cu, which, however, corresponds practically to a rang of from 16 to 26% Cu; the extremes beyond these limits being obtained during the blowing-in of the furnace and under other special conditions of working.

SYNTHESIS OF CHARGE AND ITS PRODUCTS (ORE SMELTING).

		Cu.	Fe.	S.	SiO_2.	CaO.	C.	MgO.	Zn.	Al_2O_3	Mn.	Difference (a)
Charge.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb	Lb.	Lb.	Lb.
Ore	1000	27·44	365·19	248·48	185·48	72·94	.....	26·72	25·56	9·11	7·70	31·38
Quartz	80	.....	1·16	0·26	77·43	0·18	.....	.....	.....	0·26	.....	0·71
Slag	145	1·06	56·84	2·54	44·81	12·34	.....	3·93	4·18	2·76	1·23	15·31
Coke	34	.....	0·78	0·54	2·86	.....	28·51	.....	.....	1·21	.....	0·10
Totals	1259	28·50	423·97	251·82	310·58	85·46	28·51	30·65	29·74	13·34	8·93	47·50
Deductions (as below)	428·95	25·10	65·75	235·88	6·69	1·26	28·51	0·35	15·68	1·50	0·78	47·50
Balance (+"O" to Fe, Zn and Mn)=Slag	938·24	3·40	358·22	15·94	303·89	84·20	.....	30·30	14·11	11·84	8·15	..... "O" 108·11
DEDUCTIONS.												
Products.												
Matte (20% Cu)	122·65	24·53	57·83	29·44	0·54	0·12	.....	.....	2·51	1·00	0·64	6·04
Flue dust recovered	25·71	0·57	7·92	4·24	6·15	1·14	.....	0·35	0·77	0·50	0·14	3·93
Volatilized	280·59	.....	.....	202·20	.....	.....	28·51	.....	12·35	.....	....	37·53
Totals (deducted above)	428·95	25·10	65·75	235·88	6·69	1·26	28·51	0·35	15·63	1·50	0·78	47·50

(a) Includes errors of analysis and undetermined CO_2 and O.

From the foregoing tonnages the average charge is readily calculated, a based on this and on the tabulated analyses, a synthesis of the charge and products is constructed, which, if somewhat empirical, is nevertheless both i teresting and useful. A comparison of the composition of the slag calculat from the materials charged and the results obtained by analyses varied but ve little, the results being as follows (the calculated percentages being given parentheses): Cu (0·36), 0·37%; Fe (38·183), 38·84%; S (1·70), 1·74% SiO_2 (32·39), 32·60%; CaO (8·97), 8·24%; MgO (3·23), 3·44%; Zn (1·5 1·54%; Al_2O_3 (1·26), 1·50%; Mn (0·87), 0·80%; O (11·54), 10·88%. Tot (100), 99·95%.

DATA PERTAINING TO THE SECOND OPERATION (MATTE CONCENTRATION).

	Cu.	Fe.	S.	SiO_2.	CaO.	MgO.	ZnO.	Al_2O_3	Mn.	C.	O, etc.	CO_2, etc.	Loss on Ignition.	T
Materials smelted.	%	%	%	%	%	%	%	%	%	%	%	%	%	
Matte	20·00	47·15	24·00	0·14	0·10	Tr.	2·05	0·82	0·53	.....	a 4·91	.....	.....	10
Ore	2·79	43·26	29·18	10·01	6·32	1·39	2·56	1·00	0·69	.....	.....	a 2·80	.....	10
Laboratory samplings	2·45	31·07	14·84	22·66	5·71	2·03	2·05	1·15	0·75	a17·29	.....	.....	.....	10
Quartz	.....	1·45	0·32	96·79	0·23	Tr.	.....	0·32	Tr.	.....	b 0·38	.....	0·30	9
Coke	.....	2·30	1·58	8·41	Tr.	Tr.	None.	3·56	None.	83·86	b 1·00	.....	.....	10
Products.														
Matte	49·63	25·24	23·00	0·26	Tr.	Tr.	1·53	Tr.	0·39	.....	.....	.....	.....	10
Slag	0·60	43·99	1·19	33·72	2·03	0·57	2·12	2·10	0·50	(b) 12·86		.....	.....	9
Flue dust	2·49	24·79	8·91	31·43	3·31	1·18	3·81	3·43	0·30	(a) 19·85		.....	.....	10

(a) By difference. (b) By calculation.

The second operation, in which occurs the concentration of the 20% ma to one containing 50% Cu, occupied a few hours less than three days, and, addition to the matte, 34 tons of raw ore and discarded samplings from the lab

SYNTHESIS OF CHARGE AND ITS PRODUCTS (MATTE CONCENTRATION).

		Cu.	Fe.	S.	SiO_2.	CaO.	C.	MgO.	Zn.	Al_2O_3	Mn.	Difference. (*a*)
Charge.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
0% matte	1000	200·00	471·50	240·00	4·40	1·00	.....	Tr.	20·50	8·20	5·30	49·10
Raw ore	170	4·74	73·54	49·60	17·02	10·74	.....	2·36	4·35	1·70	1·17	4·78
Laboratory samplings	34	0·88	10·50	5·05	7·70	1·94	.....	0·69	0·70	0·39	0·26	5·88
Slag	160	1·17	62·72	2·80	49·44	13·62	.....	4·34	4·61	3·04	1·36	16·90
Quartz	330	.....	4·78	1·06	319·41	0·76	.....	Tr.	.....	1·06	Tr.	2·93
Coke	95	.....	2·19	1·50	7·99	Tr.	79·67	Tr.	.....	3·38	.....	0·27
Totals	1789	206·74	625·29	300·01	405·96	28·06	79·67	7·39	30 16	17·77	8·09	79·86
Deductions (as below)	763·36	199·61	104·33	285·86	4·81	0·40	79·67	0·14	6·60	0·47	1·61	79·86
Balance (+ "O" to Fe, Zn and Mn)=Slag	1182·18	7·13	520·96	14·15	401·15	27·66	.....	7·25	23·56	17·30	6·48	"O" .....156·54
DEDUCTIONS.												
Matte (49·63%)	401·60	199·31	101·36	92·18	1·04	Tr.	.....	Tr.	6·14	.....	1·57	.....
Flue dust recovered	12	0·30	2·97	1·07	3·77	0·40	.....	0·14	0·46	0·47	0·04	2·38
Volatilized	349·76	.....	.....	192·61	.....	.....	79·67	.....	.....	.....	.....	77·48
Totals	763·36	199·61	104·33	285·86	4·81	0·40	79·67	0·14	6·60	0·47	1·61	79·86

(*a*) Includes errors of analysis and undetermined CO_2 and O.

atory were smelted, the ore being added to the charge to keep the tenor of final matte from rising too high for comfortable running.

A comparison of the calculated and actual composition of the slags during the second operation is as follows (the calculated percentages being given in parentheses): Cu (0·60), 0·60%; Fe (44·07), 43·99%; S (1·20), 1·19%; SiO_2 (33·93), 33·72%; CaO (2·34), 2·03%; MgO (0·61), 0·57%; Zn (2·00), 2·12%; Al_2O_3 (1·46), 2·16%; Mn (0·55), 0·50%; O (13·24), 12·86%. Totals (100), 99·74%.

The average daily capacity of the furnace, including both operations, was 60 tons raw ore, or 115 tons of roasted ore. In the former case granulated slag was used throughout the test run, and a daily average equivalent to 80 tons raw ore, has been repeatedly attained when lump slag was available. Hot blast would probably increase the smelting capacity, but with a Herreshoff furnace of the dimensions of the one used, the additional tax for fuel, coal heavers and firemen was found to be economically prohibitive.

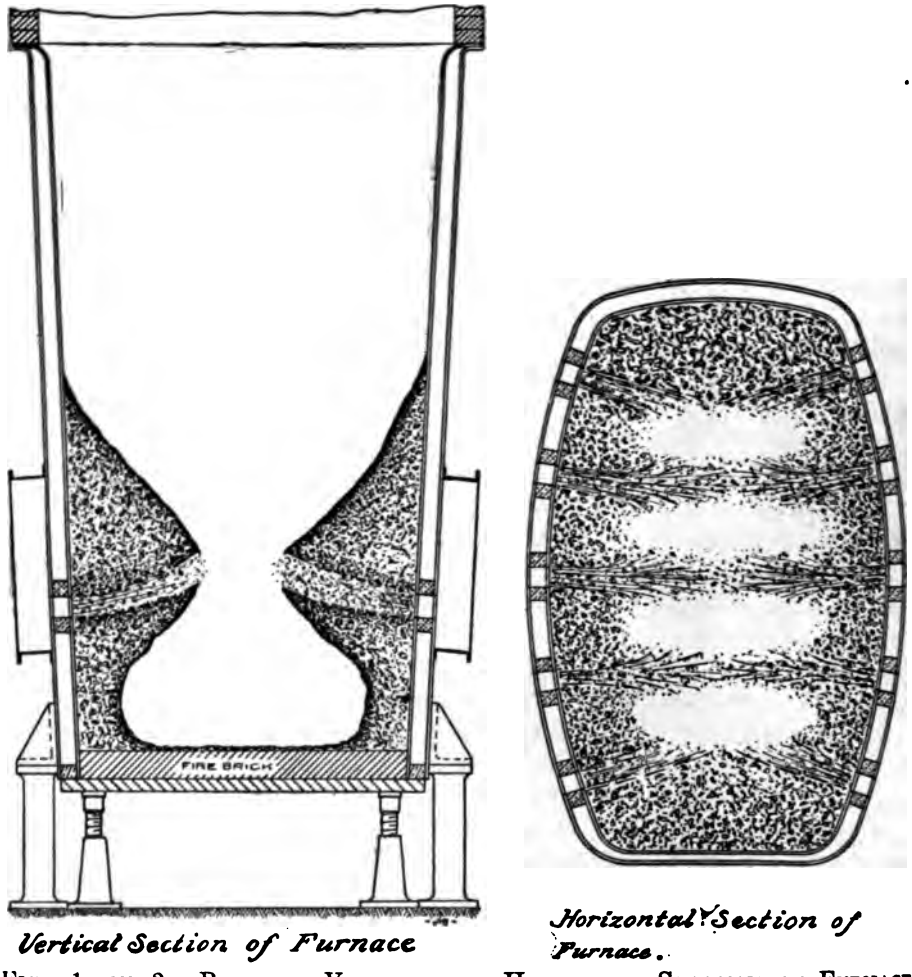
The average volume of the blast was 4,500 cu. ft. of air per minute at a pressure of 17 oz. per sq. in. Some incrustation forms around the furnace top, but not in sufficient quantity to be troublesome. At the region of the tuyeres, however, a porous friable accretion bridges the furnace from wall to wall. Light is rarely discernible on punching the tuyeres. It may seem unreasonable, but it is nevertheless true, that a bar has been driven through the furnace, entering a tuyere on one side, and withdrawn from the opposite tuyere by the naked hand.

It is my belief that this condition, alarming as it would seem in ordinary smelting practice, is essential to satisfactory concentration. The condition encountered in barring the tuyeres leaving no doubt that, for a certain area surrounding each tuyere, the furnace is bridged from wall to wall and the molten matte and slag must find its passage into the crucible through channels between the tuyeres. The vertical and horizontal sections of the furnace during the operation would probably appear as shown in Figs. 1 and 2, on the following page.

Granting the condition described, *the effect is* that the column of charge rest-

ing upon boshes and bridge, undergoes a partial roasting in its descent, and a rapid, fierce oxidation as it reaches and is held in the constricted channels. The charge sinks evenly and uniformly, rarely showing a hot top. The slags run hot and fluid; in fact, the furnace gives less trouble throughout than those smelting roasted ore.

The concentrations effected were 7·3 into 1 in the first operation, and 2·5 into 1



Vertical Section of Furnace

Horizontal Section of Furnace.

FIGS. 1 AND 2.—PROBABLE VERTICAL AND HORIZONTAL SECTIONS OF FURNACE WHILE IN OPERATION.

in the second, but these by no means represent the limits attainable. Contrary to the experience of many, the reconcentration of the first matte presents no difficulties at Ducktown. There is no limit within the range of matte to the second operation. A 6% matte may be brought up to a 50% one quite as successfully as an initial matte of higher grade.

Occasional samples of 70% matte have been assayed from the reconcentration *of a 10% initial* matte, but such conditions, if permitted to continue, would

composition of the slag was as follows: SiO_2 41·50%, Al_2O_3 8·42%, FeO 19·28%, CaO 29·23%, MgO 0 3%, Cu_2O 0·45%.

The Trail Smelter.—(Through the courtesy of W. H. Aldridge.)—This plant, known as the Canadian Smelting Works, situated at Trail, B. C., has a capacity of about 1,300 tons of copper and lead ores per day. It is operated by electrical power from a station on the Kootenay River, 30 miles distant. The current of 20,000 volts is transformed at the smelter to 550 volts, and used to drive 16 motors aggregating 1,000 H.P., besides a lighting plant which furnishes the smelter and the town of Trail. The ores are purchased from all parts of British Columbia and are of such varying character that great care must be exercised in handling and sampling. The copper-gold ores, which are furnished mostly by mines in the Rossland district, carry the chief values in gold, the tenor in copper being low. These ores are delivered at the smelter in 30-ton hopper bottom-dumping cars, which discharge directly into large receiving bins in front of the copper sampling mill. The ore is drawn from the bins into transfer cars, dumped into a No. 6 Gates crusher, having a capacity of 100 tons per hour, and crushed to 3-in. size; the ore is then elevated by a large bucket elevator to the first automatic Vezin sampler. This sampler takes 17 samples per minute, an amount equal to one-tenth of the entire lot. The sample from this machine is then crushed to 1·5 diameter by a No. 3 Gates crusher, after which it passes to No. 2 Vezin sampler, which takes 34 samples per minute, or one-fifth of the original sample, being one-fiftieth of the original lot. This sample is again reduced by crusher and rolls to 0·25 in., after which it passes to the third sampler, taking 42 samples per minute, and one-tenth of the second sample, or one-five-hundredth of the original lot. This sample is further rolled and divided by Jones riffles, until it weighs about 20 lb. It is then taken to the assay office for further crushing and reducing. The ore from the mill is either taken to the roasting yard and roasted in heaps of 3,000 tons each, or transferred direct to the blast furnace charge bins. There are three large copper furnaces, aggregating 900 tons capacity. The ores and fluxes are fed directly from cars into the furnaces, hand-feeding having been discontinued. As the plant is built on a sloping site, every advantage is gained by gravity, which reduces elevating and shoveling to a minimum, leaving nothing but final products to be elevated. All transferring and hauling is done by electrical locomotives of 10 H.P. each. A description of the methods used in handling and treating the lead ores will be found under "Lead," elsewhere in this volume.

The Granby Smelter.—The capacity of this plant is to be increased by the construction of two new furnaces—making six in all—which will enable it to handle 2,200 tons of ore daily, or about 800,000 tons per annum. The furnaces are to be of the standard type, built by the Allis-Chalmers Co., and will be supplied with automatic charging devices. New electrical equipment will also be installed to provide the extra power needed in the enlarged works.

New Copper Smelter at Crofton, B. C.—The construction of the copper smelting works at Crofton, Vancouver Island, was completed late in 1902. The plant is situated on Osborne Bay, about 40 miles by rail from Victoria, and is owned by the Northwestern Smelting & Refining Co. The furnace building, whic

composition, although those made by the larger furnace not uncommonly contained from 2 to 3% more of iron. A monthly average of the 44-in. furnace was about 215 tons per day, of the 56-in. furnace, 420 tons, with a range for the latter of from 400 to 500 tons. As the former had 30·5 sq. ft. of hearth area, its average was 7·06 tons per sq. ft. of hearth; the latter had 70 sq. ft. of area, and its average was 6 tons per sq. ft. of hearth. The 44-in. furnace required 19 oz. blast, the 56-in. furnace required 27 oz. blast and about 10% more fuel. A comparison of these results seems to show that the advantage lies with the narrower type of furnace, both in regard to the tonnage smelted per sq. ft. of hearth area and the economy of power for blast pressure. This conclusion is substantiated by the results obtained from a trial run with a still narrower type of furnace, measuring 35×122 in. at the tuyeres. This furnace showed a maximum capacity of 344 tons, or 11·25 tons per sq. ft. of hearth area, while consuming 7% coke.

Mr. William A. Heywood states that the two 56×180-in. furnaces of the Tennessee Copper Co. during a run of 28 days, smelted a total charge, not including coke, of 30,095 tons, or 1,074 tons per day for the two furnaces. The total ore smelted was 36,757 tons, and the coke used was 3,269 tons. The slags contained an average of 0·44 Cu. There were 54 men and boys employed in the blast furnace department per day of 24 hours, so that the charge smelted daily was about 20 tons for each person employed. Mr. Heywood is not in favor of using the factor of tonnage per sq. ft. of hearth area as a standard for gauging the efficiency of a furnace, and he states that the results on this basis throw the advantage to the smaller furnace without regard to the factor of economy. The best size of a furnace must be determined by actual experiment in each case, and tonnage is only one of the elements to be considered. Experience in copper as well as in iron smelting appears to indicate that the larger furnaces are the more economical.

Mr. James W. Neill expresses the opinion that the width of the furnace should conform to the physical conditions of the ore; that for coarse ore, which has been previously roasted, the width is limited only by the penetrating power of the blast, while fine material charged in a wide furnace results in a heavy mass, through which the blast penetrates only with difficulty. In such a case, "blow-holes" are formed with the production of large quantities of flue dust and consequent losses.

The results reported by Mr. Metcalfe have reference to the new smelting plant of the Anaconda Copper Co. The furnaces as originally constructed were 56×180 in. at the tuyeres, 72×180 in. at the top of the jackets, and 18 ft. from tuyeres to charging floor. They are charged by hand dumping of coke barrows and mechanical dumping of large tram cars containing approximately 5,000 lb. each.

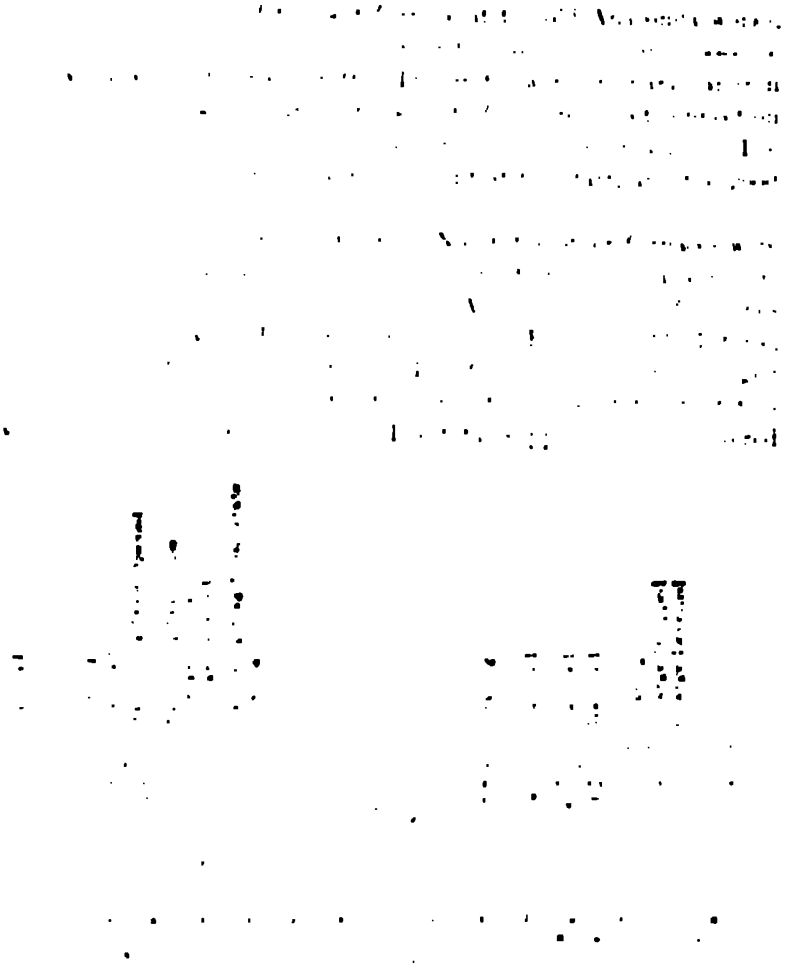
The materials used are Butte ores, coarse concentrates and briquettes of flue dust and slimes fluxed by converter slag and limestone. On first starting up considerable trouble was experienced from heavy crusts forming on the ends and sides of the jackets. Much of the end crusting was done away with by cutting off the end tuyeres—originally there were 12 tuyeres in front, 14 at the back, and 3 at each end—but the side crusts seemed to be due to improper distribution

increase in tonnage per sq. ft. of hearth area, certainly do not indicate that the narrower width is in itself a commercial advantage in smelting such materials. The results with No. 6 which show a slightly decreased tonnage but an increased grade of matte, and a slightly decreased power expense owing to the lower blast pressure, may be held, however, to indicate a commercial advantage for the 48×180-in. furnace of 15 ft. depth in a plant where cost of converting is an important item.

Reverberatory Furnaces for Smelting Copper.—(By E. P. Mathewson.)—Probably the largest installation of reverberatory furnaces built in recent years for the smelting of copper is that of the Washoe Copper Co., at Anaconda, Mont. The plant consists of 14 furnaces, originally 20×50 ft. hearth measurement, set back to back in two rows and housed in two steel buildings substantially built and well ventilated. Between these buildings is a chimney 225 ft. high, 20 ft. internal diameter, constructed of steel and lined with brick, the connections to the furnaces being made by four main flues. One feature of the original construction was an arrangement for pre-heating the air by the heat of the escaping gases and the heat radiated from the bottom of the hearth. The air was admitted first to a brick chamber built around the brick-lined steel pipe, which carried the waste gases to the main flue; thence the partially heated air passed beneath the bottom of the furnace in a narrow channel, passing from the front to the back four times before rising in a cast iron box to the top of the furnace; thence to a sheet steel box above the bridge wall, being finally admitted to mix with the gases from the fire box, through checker work in the roof above the bridge wall, the draft of the furnace being sufficient to draw in the hot air. In remodeling the furnaces this arrangement was omitted, as it was considered more important to retain the heat in the bottom of the furnaces than to use it for pre-heating the air furnished to the top of the charge, more rapid smelting being accomplished by keeping the matte in the furnace as hot as possible.

In building the plant, every convenience to facilitate the handling of materials was arranged for. The ashes from ash pits are sluiced away by waste water from the concentrating department, and the slags are granulated and washed away to the dump by the same means. The matte is tapped from time to time into large ladles holding 11 tons and drawn by compressed air locomotives to the converting department, where the still molten matte is dumped from ladle to converter to be blown to copper. The air necessary for the combustion of the fuel was forced under the grates by fans, the ash pit being closed by cast iron doors. Each furnace had an average daily smelting capacity of 100 tons of calcines. The fuel used was obtained from Diamondville, Wyo., and consisted of "run-of-mine" coal of the following composition: Water, 1·6%; volatile combustible, 38·7%; fixed carbon, 49·2%, and ash, 10·5%. This coal gives very satisfactory results under natural draft, but with forced draft, it does not act so well.

In the former practice, the time lost in grating the furnace averaged three hours per day per furnace, and during the grating (which occupied one-half *hour at a time*) the front of the furnace became cooled and the slag frequently *set near the skimming*-door. At the suggestion of Capt. W. M. Kelly, Furnace



Under the improved conditions of working, the aggregate cost of coal, labor and repairs has been reduced by more than $1,000 per day. The following de-

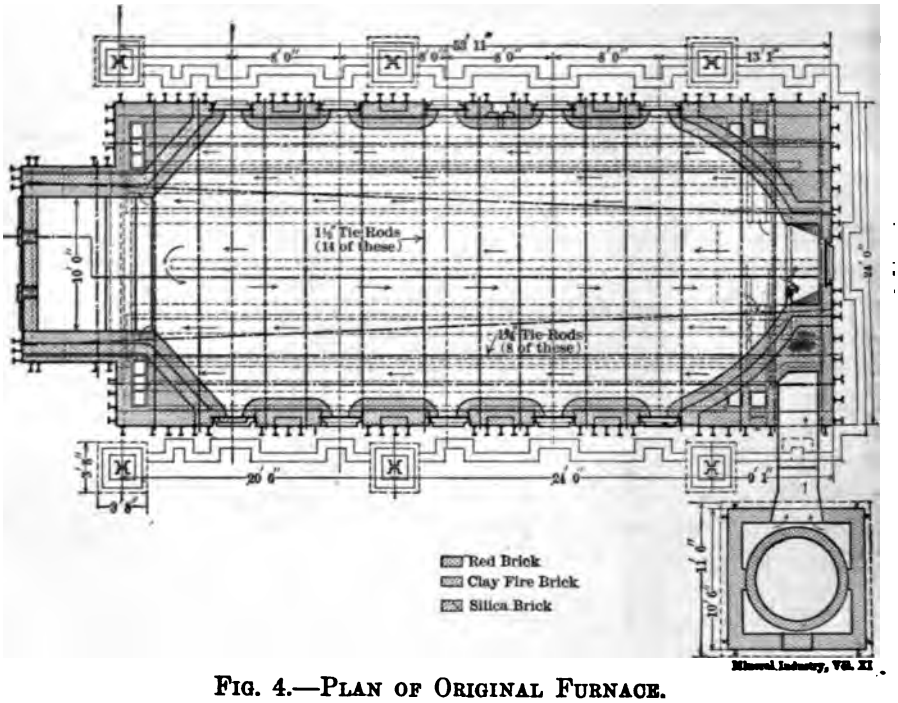


FIG. 4.—PLAN OF ORIGINAL FURNACE.

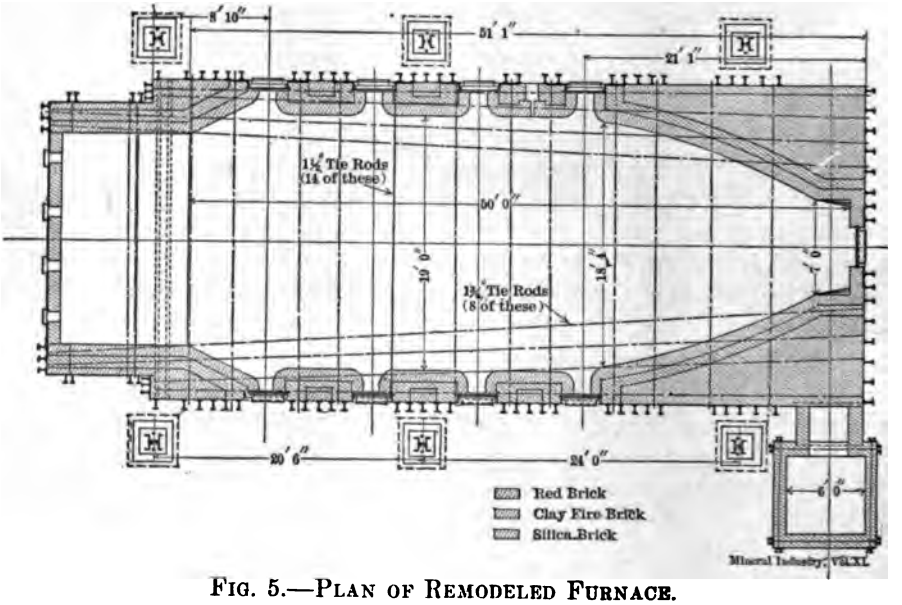
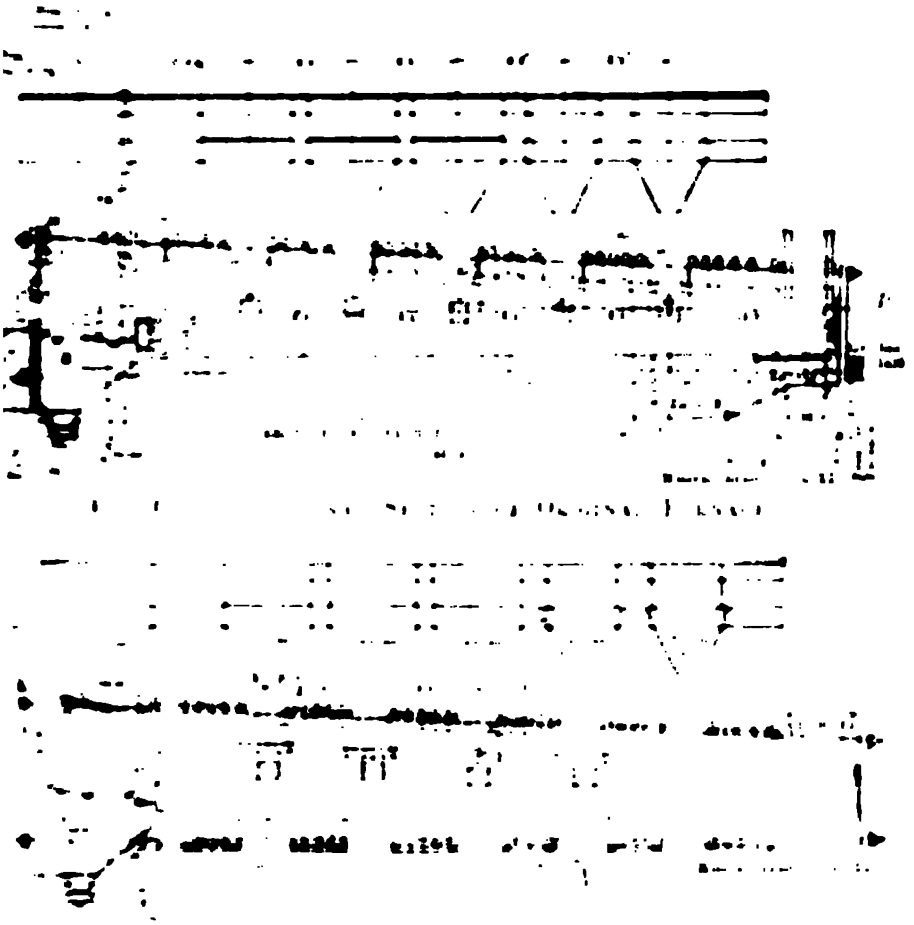


FIG. 5.—PLAN OF REMODELED FURNACE.

tails of furnace operations are of interest: Draft in Down-take=1·5 in. of water: *Analysis of material* charged.—Cu, 10·5%; SiO_2, 33·2%; FeO, 39·5%; S, 7·8%.



independently upheld by iron columns, instead of resting the entire weight of the structure on the bottom of the furnace, as in former construction. The Colorado Iron Works installed this device at two furnaces for the Westinghouse interests near Ely, Vt., and the furnace of the Grand Prize Copper Co., of Gila County, Ariz.

The jack-screw supports (Fig. 8) and the familiar iron bottom of former practice are retained as integral parts of this new furnace bottom. The jack-screws are supported on and bolted to two I-beams extending the length of the furnace and placed immediately beneath and parallel to its sides. These I-beams are bolted to and supported by three steel axles equipped with small flanged wheels, the whole constituting a carriage which runs freely on a track. The entire apparatus is movable or rigid at will, for the wheels are easily braced if the tension of the tightened jack-screws does not serve to hold it in position. The jack-screws have a play of 10 in., and the false bottom is 9 in. deep, including the firebrick cover.

The time occupied in cleaning and preparing a frozen furnace for active service is lengthened by the necessity of working in a confined place where the temperature is uncomfortably high and the débris must be removed from the bottom of the furnace before the false bottom of fire clay, coke-breeze, etc., can be repaired or replaced; furthermore, the superimposed bottom is almost invariably destroyed when the iron plate is pried from the supporting jack-screws, and no renewal is practicable until the plate is once more installed beneath the furnace. These disadvantages are for the most part removed by the use of the truck support. Working results have shown a reduction of at least 50% of the time lost by the freezing up of a furnace. The work of barring down and renewing the false bottom proceeds simultaneously.

The Garretson Furnace.—Oliver S. Garretson, assignor to Garretson Furnace Co., Pittsburg, Pa., has patented[11] a process of matte or pyrite smelting which consists in subjecting the molten matte to a converting or Bessemerizing blast underneath a column of material which contains a flux, removing the slag, and subjecting the slag to the action of a blast underneath a column of sulphur-bearing material.

The Treatment of Low-grade Siliceous Copper Ores.—(By Edward D. Peters.)[12] —The processes which appear economically applicable to the treatment of low grade siliceous copper ores are: (1) Direct smelting; (2) mechanical concentration, followed by the smelting of the concentrates and the lixiviation of the tailings; (3) lixiviation of the ore direct with a solution of ferrous chloride and salt; (4) lixiviation of the ore direct with hydrochloric and sulphuric acids, which are regenerated in the solution by the precipitation of the copper from a chloride solution by means of sulphurous acid; (5) lixiviation of the ore direct with sulphuric acid; and (6) the Rio Tinto method of gradual lixiviation in heaps.

1. Direct Smelting.—Wherever it is in any way practicable, the American met-

[11] United States Patent No. 728,701, May 19, 1903.

[12] Abstracted in the *Engineering and Mining Journal*, June 6, 1903, from a paper and discussion, read before the Institution of Mining Engineers, Newcastle-upon-Tyne, England, May and December, 1902. Mr. Peters' paper is a contribution to the discussion of an article by Mr. E. J. Muir, in which the latter gave results of tests made upon an Australian siliceous copper ore. For the interpolations, given within parentheses, the Editor of the *Engineering and Mining Journal* is responsible, and not Dr. Peters. The discussion is reproduced because it concerns a practical subject and gives the views of an authority.

Without attempting to analyze his experiments in detail, Mr. Peters would simply point out that the results of Mr. Muir's concentrating tests show a saving in the concentrates amounting to about 20% of the original copper contained in the ore, and a loss of nearly 80% in the tailings. This, of course, means no concentration whatever, and there must be some reason, not apparent, why Mr. Muir attempted to concentrate at all.

If a portion of the copper in the ore were present in the shape of some mineral that would exercise an injurious effect upon the subsequent lixiviation, and if this mineral had a higher specific gravity than the remainder of the sulphides present, there might be some question of attempting to remove it by concentration. But, as the 20% of the copper that was removed by concentration had, as Mr. Peters understands, exactly the same chemical composition as the 80% left in the tailings, he fails to see the use of employing concentration; nor does he believe that these ores should be subjected to concentration. (It will be understood that Mr. Peters is referring solely to the ordinary methods of wet-concentration in making this statement, and that he is not expressing any opinion as to the results that might be obtained by one or two novel patented methods of which he has no personal experience.)

It seems to Mr. Peters most advantageous, therefore, to subject the entire mass of ore to lixiviation, rather than to complicate matters and increase expenditure by any preliminary concentration.

3. Lixiviation of the Ore Direct with a Solution of Ferrous Chloride and Salt (old Hunt & Douglas Method).—Considerable quantities of ore have been successfully worked by this process in the United States. The method depends upon the fact that copper oxide is decomposed by ferrous chloride solutions, forming insoluble ferric oxide, while the copper goes into solution as cuprous and cupric chlorides. It is precipitated in a very pure metallic form by iron, the ferrous chloride solution being thus also regenerated, and requiring only the addition of a little salt to fit it for further use. The consumption of metallic iron in this method is very small, since much of the copper is in solution as cuprous chloride. As the copper must be in an oxidized form in order to go into solution quickly and thoroughly, the ore will require a preliminary roasting of sufficient thoroughness to convert most of the copper present into oxide or sulphate. This means that the ore must be crushed dry, though not to nearly so fine a state as would be required for its concentration. Therefore, instead of wet-crushing followed by concentration, the writer would suggest dry-crushing followed by roasting.

It is impossible to make a comparison of the costs of these two different plans of operation without being accurately acquainted with the physical and chemical character of the ore under consideration. By the use of modern high-speed rolls of great diameter and weight, and of the automatic reverberatory roasting-furnaces so general in use in the United States and elsewhere, the cost of dry-crushing and roasting should not exceed the cost of wet-crushing and concentration, while the condition of the pulp for lixiviation is incomparably better when *produced by the former* treatment. Apart from the advantage gained by the *coarser condition of the* pulp, and the much lesser proportion of very fine powder,

vert the copper compounds into oxides, as sulphurous acid does not attack sulphides. The ideal ore is one carrying copper oxides or carbonates in a siliceous gangue; lime and magnesia are objectionable, as they dissolve in sulphurous acid and, while they do not materially interfere with the reactions, they consume a certain amount of sulphur and so increase the cost of the process.)

Sulphurous acid produced by roasting pyrite is the cheapest chemical procurable in the western country, and the plant is much simpler than that used in making sulphuric acid. A unit of copper converted into cuprous sulphite requires but half the sulphur that would be required to convert it into cupric sulphate. Cuprous sulphite is precipitated from the solution without the use of scrap iron, which is a great advantage in remote districts. In southern Utah, for instance, scrap would cost from $40 to $50 per ton, and from 2·5 to 3·5 lb. iron are required to precipitate 1 lb. of copper from sulphuric acid solutions, owing to the large amount of basic salts formed. Sulphurous acid dissolves very small amounts of other metals that may be in the ore, and the precipitated cuprocupric sulphite is practically pure and furnishes pure copper by a simple smelting operation.

6. The Rio Tinto Method of Gradual Lixiviation in Heaps.—Mr. Peters agrees with Mr. Eissler in having a strong leaning toward this process of slow, but inexpensive, lixiviation, in cases where the climate is suitable, and where the chemical and physical condition of the ore favors the gradual and persistent formation of sulphates. (In the Rio Tinto method the poor coarse ore is built up in the form of large conical heaps, 10 to 15 ft. high and about 20 to 30 ft. apart. A fire is then lighted in each of these and the mixed lump and fine ore is filled in between them. The gas produced by combustion mixes with the steam generated from the moistened mass and permeates the whole mass of 4,000,000 tons of ore. After burning slowly for a period of four to six months, water is turned on so as to dissolve out the copper sulphate. This percolation and leaching process continues for about five years, the liquor being caught below in dams or large reservoirs built of masonry, the copper being precipitated on scrap iron.[14])

At certain Portuguese mines, such as the San Domingo works, a slow process by weathering was formerly employed on pyrites containing copper. For this treatment the soft, more permeable ores are best adapted. Heaps, containing from 100,000 to 250,000 tons of material, are built up, their assay content ranging from 1·5 to 2% Cu. About 88% of the total copper is extracted in the course of six years, the remaining 12% being recoverable only by a long and unprofitable continuance of the same treatment. At San Domingo as much as 3,000,000 tons have been under treatment at a given period. Plenty of stone flues are distributed on the surface of the ground and the mineral is dumped over them. These flues are connected one with another longitudinally and transversely, and at intervals they communicate with the outer air by vertical stone shafts. The object of this arrangement is, of course, to provide a plentiful supply of air in order to prevent the heaps taking fire. This last is detrimental because the sintering of the material obstructs the subsequent leaching of the copper.

Before precipitating the copper it is necessary to reduce the ferric salts present

[14] THE MINERAL INDUSTRY, Vol. II., p. 286.

$3CuSO_4+3SO_2+4H_2O=Cu_2SO_3.CuSO_3+4H_2SO_4$; $Cu_2SO_3.CuSO_3+4H_2SO_4=Cu+2CuSO_4+2H_2SO_4+2SO_2+2H_2O$. By neutralizing the solution and reheating, 50% of the copper remaining in the solution may be precipitated. Instead of neutralizing, the solution may be used to leach fresh ore, and the process repeated. The precipitated copper may be directly melted and cast, or if impure, it may be added to the furnace charge. The solution used to leach the ore dissolves iron and other metals present, as well as copper; these impurities accumulate in it and must be removed from time to time, which can be done easily by neutralizing the solution, heating, and injecting air, whereupon the iron is precipitated, carrying down the other impurities. Before leaching the ore, any sulphur dioxide present in the solution must be removed, which is accomplished by heating.

Proposed Process of Extracting Copper from Its Ores.—Adolf von Gernet has patented[17] a process of extracting copper from its ores, which consists in slowly passing the ore in the form of pulp through a current of sulphurous acid passed in a direction opposite to that of the travel of the pulp.

Elimination of Impurities from Copper Matte.[17a]—(In connection with the following experiments on the relative rates and points of elimination of impurities during the Bessemerizing process, reference may be made to the article on "The Elimination of Impurities from Copper Mattes," which appeared in THE MINERAL INDUSTRY, Vol. IX.)—According to W. Randolph Van Liew, a converter was selected which was starting on its second charge. The first charge after lining had finished its copper "hot," and consequently no copper was adhering to the sides of the lining. All the copper and granulated slag from the previous charge were dumped, thus removing any possibility of "salting" the matte to be tested. The converter worked fast and well during the entire test. Periods of ten minutes were selected. The converter was brought from the stack to secure each sample of matte to be analyzed, and only that time counted during which air was being forced through the charge.

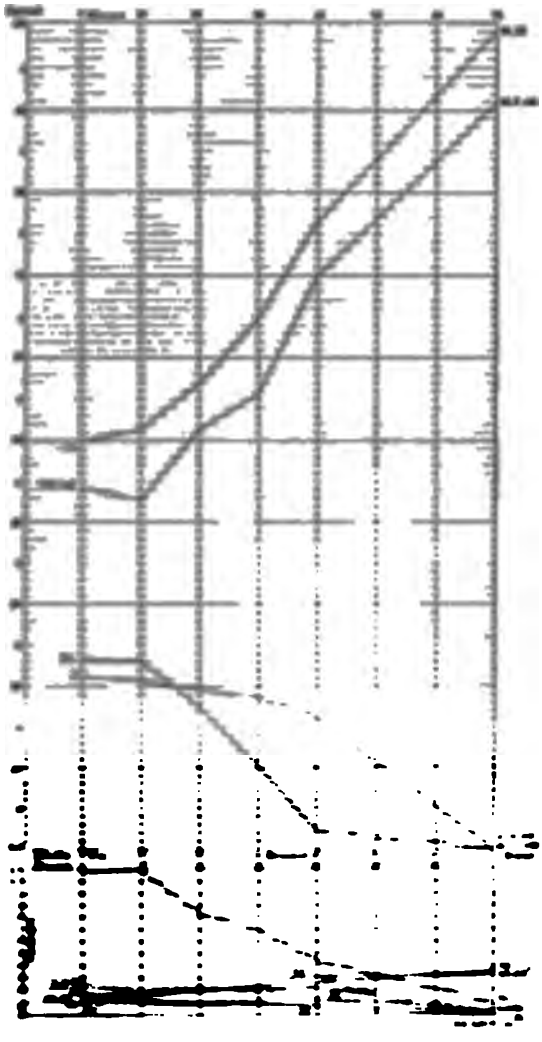
At the end of 40 minutes' actual blowing, the matte was up to white metal, the point at which the last skimming takes place; that is, matte of approximately 76·4% Cu. From this point, of course, average samples of the contents of a converter are impossible, since from this skimming point up to finished copper, the contents of a converter consist of constantly varying proportions of matte and copper, which, when a converter is brought from the stack and the blast-pressure turned off, settle according to their specific gravity. When the charge is completed, a granulated sample of finished copper is obtained and assayed. Accurate chemical analyses of these equal-period samples of matte and copper are given in the table on the following page.

The accompanying illustration (Fig. 9) shows graphically the course of the process of elimination. In this figure, the line of abscissa represents the 10-minute periods of blowing, and the ordinates represents percentages of copper, etc., from 0 to 100. The ordinates of the figures at the bottom are the same, *but on a larger scale* (from 0 to 1·2%), to show better the impurities in the matte

[17] *United States Patent No. 717,565, Jan. 6, 1903.*

[17a] *This article, which appeared in the Engineering and Mining Journal, June 27, 1903, is to be read before the autumn meeting of the American Institute of Mining Engineers.*

[illegible] a few tenths of 1%. The upper diagram shows that [illegible] the enrichment of the matte in copper.



The lines showing the relative elimination of the iron and the sulphur are the most interesting. For the first 10 minutes of the blow, and while the matte is heating up, the iron and sulphur lines are parallel. From this point there is a marked change; the sulphur line is very gradual in its drop, showing that but little is being burned in comparison with what is taking place with the iron, whose line takes a sudden drop. The iron decreases during 30 minutes from 23·15% to 2·4% at the skimming point, while at this point there still remain 16·3% of sulphur in the matte. From this point, however, to blister copper, it is the sulphur that bears the brunt of elimination, the iron dropping only from 2·4% to 0·0038% at blister copper, while the sulphur decreases from 16·3% to 0·15%. This is of great interest, as it shows that up to the skimming point, it is the oxidation of the iron to ferrous oxide, and the union of the ferrous oxide with the silica of the lining, that affords the source of heat to carry on the operations within a converter; while from the skimming point (76·4% copper) to the finished blister copper it is chiefly the burning of the sulphur that gives the heat supply to finish the work started by the oxidation of the iron. The zinc is scarcely affected during the "heating-up" period; while after that its elimination is gradual. The arsenic and antimony curiously enough, are but slightly affected during the whole of the slag-forming period, or as long as enough iron remains to be slagged off. At the cupola-tap of matte into the converter, the arsenic amounted to 0·11%, and the antimony to 0·14%, while at the end of the slag-forming period the arsenic amounted to 0·08% and the antimony 0·13%. When the iron in the matte had been oxidized and slagged off the arsenic and antimony began to be oxidized and driven off, until, at the point of blister copper, but 0·0012% of arsenic and 0·006% of antimony remained.

Process for Treating Copper Matte.[18]—A patent has been issued to Messrs. Herman Thofern and B. D. St. Seine for a process of treating copper matte by blowing into the furnace a mixture of superheated steam, air and fine sand. This idea of simultaneously oxidizing and scorifying the metallic substances to be eliminated is not new, as it has been incorporated previously in patents issued in the United States and Great Britain. With matte containing 30% Cu, a rather large proportion of silica is used at first in the blast, and the oxidation and scorification proceeds very rapidly. The fusible slag collects on the surface of the bath outside of the blast zone, so as to protect the walls of the furnace. From a charge of 50 tons, most of the iron is slagged, and the sulphur driven off as dioxide in about six hours, the product being a matte of 80% Cu. At this stage in the operations, the proportion of sand in the blast is reduced, or the same proportion is used intermittently to slag the remainder of the iron and to burn off the last of the sulphur; while antimony, arsenic, phosphorus and similar impurities are converted by the hydrogen of the steam into volatile compounds and are thus eliminated. There is obtained finally a copper bath with about 99% Cu which can be cast into anodes, or further refined in the usual manner.

In this connection it is interesting to note the method patented[19] by George *Mitchell of converting* copper matte into metallic copper, which consists in feed-

[18] *United States Patent* No. 723,500, March 24, 1903. [19] United States Patent No. 719,458, Feb. 3, 1903.

Progress in the Electrolytic Refining of Copper in 1902.*

By Titus Ulke.

Electrolytic Copper Refineries.—The world's average daily production of el trolytic copper at the close of 1902 was about 883 short tons, of which 764 to or 86·5%, were supplied by the United States. Of the balance amounting 119 tons daily production, or approximately 13·5%, Great Britain furnishe little over 8·8%, Germany about 2·75%, and France a little over 1·6%. T United States now produces at the enormous rate of 278,860 tons of electroly copper per annum valued approximately at $72,503,600. The by-product covered daily contains about 74,100 oz. silver and 948 oz. gold, which equals annual output of over 27,000,000 oz. of silver, valued at nearly $13,000,000, a more than 346,020 oz. of gold, valued at $7,152,233. According to the Uni States Treasury Bureau of Statistics, the copper exports from this country c sist chiefly of electrolytic copper, and for the year 1902, they represented a va of $45,485,598, as compared with $33,534,899 in 1901. The value of the (ports of copper was exceeded only by the value of the exports of manufactu iron and steel and of mineral oils.

There are now in active operation, or ready to be placed in commission, electrolytic copper refineries in the world, not including the plant of the Os Electrolytic Refining Co. now being constructed at Osaka, Japan.

During the past year there has been a notable increase in the quantity of c centrates from the Michigan copper mines cast into anodes and treated electro tically, and for several years a large part of both the Tamarack and the Calun & Hecla output has been refined electrolytically at Buffalo. The Quincy Mini Co. casts certain grades of argentiferous "mineral," and ships the metal East f electrolytic refining. The Isle Royale Copper Co. has found that it more th pays to save the silver, with the small difference between the price of Lake a electrolytic copper. It is reported that the copper from the Mass mine frequen carries $65 in silver per ton of ingots. As all Lake copper, judging from num ous analyses, carries noticeable quantities of silver, it is only a question of tin in my opinion, when all the fine copper produced in the United States will be ma electrolytically, and only minor distinctions of brand will remain.

It is probable that an electrolytic refinery for treating the converter copp produced on the Pacific Coast will be built on Puget Sound; water power in lar units is available here at a price per horse-power-year considerably lower than equivalent, generated from coal, at the large refineries on the Atlantic seaboa and lumber also is much cheaper. Even though the cost of labor and of m supplies is 60% greater in Seattle or Tacoma than in New York or Baltimo there would still be a margin in favor of refining on Puget Sound. The refine if established, should be operated in conjunction with a plant for turning out f main part of the metal in the form of sheet copper and wire to supply the gr ing demand for these materials in the Orient, Australia and the west coast South America, as well as that of the western part of the United States.

* *The growth and technique of the electrolytic copper industry has been fully discussed by Mr. Ulke in work, Modern Electrolytic Copper Refining*, New York, 1903. Much of the information contained in this t *has appeared in previous volumes of* The Mineral Industry.

the fact that the percentage of scrap copper produced with the heavy anod only about one-half that made with light anodes, say, 7% as compared with a 15%, the weight of the scrap falling being approximately the same in both c

Regeneration of Foul Solutions.—The American Smelting & Refining is introducing at its Perth Amboy plant the essential features of the Ott Hofmann method[3] for the purification of foul electrolytic solutions. This pr

ELECTROLYTIC COPPER REFINERIES IN THE UNITED STATES OPERATED IN 1

Number.	Name of Company and Location of Works.	Kind of Material Chiefly Treated.	Approximate Daily Copper Output in Tons (2,000 lb.)	Number and Capacity of Generators. Kw. = Kilowatts.	No. of Tanks in Refinery.	Arrangement of Electrodes.	Approx Daily C of Gol Silver Slim
1	Raritan Copper Works (United Metals Selling Co.), Perth Amboy, N. J.	Converter Copper from Boston & Montana, Butte & Boston, Old Dominion, Arizona Copper Co., Copper King, Ltd., United Verde, Bingham, Greene Cons. and Highland Boy.	150 to 200 (Cap. 200)	Five @ 600 Kw.	1,600	Multiple.	8,000 10,000 o 175 200 oz.
2	Guggenheim Refinery, Perth Amboy plant of Amer. S. & R. Co., Perth Amboy, N. J.	Anodes and pig copper from Mexico, Utah and Colorado.	100 (Cap. 150)	Three @ 520 Kw.	816	Multiple.	25,000 o 200 oz.
3	Anaconda Mining Co., Anaconda, Mont.	Anaconda anodes.	84 (Cap. 150)	Three @ 240 Kw. Two @ 360 Kw. Four @ 220 Kw.	1,490	Multiple.	4,207 oz 25 oz
4	Baltimore Smelting & Rolling Co. (Baltimore Copper Works), Baltimore, Md.	Converter copper from Anaconda, Mt., Lyell and part of the Germania Works output.	80 (Cap. 100)	Eleven @ 80 Kw.	540	L. p. series. S. p. multi.	6,400 o 28 o
5	Boston & Montana Cons. Copper and Silver Mining Co., Great Falls, Mont.	Boston & Montana anodes.	75	Two @ 810 Kw.	324	Multiple.	5,000 o 70 o
6	Nichols Chemical Co., Laurel Hill, N. Y.	Converter copper from the Mountain Copper, United Copper, Copper Queen and Granby Co. and metal from Canadian and Spanish pyrites cinders.	120	Six @ 75 Kw.	120	Series.	6,000 o 204 o
7	Balbach Smelting & Refining Co., Newark, N. J.	Orford anodes and miscellaneous.	45 (Cap. 50)	One @ 300 Kw. Two @ 125 Kw.	480	Multiple.	3,000 o 15 o
8	De Lamar Copper Refining Works, Carteret, N. J.	Blister copper from Bully Hill mines, Cal.	50	One @ 520 Kw.	408	Multiple.	10,000 o 200 o
9	Buffalo Smelting Works, Black Rock, N. Y.	Lake Superior, argentiferous native copper "mineral."	30	One @ 510 Kw. Two @ 48 Kw.	270 490	Multiple.	600 o — o
10	Chicago Copper Refining Co., Blue Island, Ill.	By-products and miscellaneous pig copper.	5	Two @ 64 Kw.	250	Multiple.	100 o 3 o

requires the electrolytic to be first neutralized, which is done by adding to it cu oxide (roasted copper matte), the bulk of solution obtained being incre This increase may be worked off in two ways. (1) By treating the su solution in a separate system of tanks in which lead anodes and cathodes are u copper being recovered, while sulphuric acid is set free and used to acidify *part of the electrolyte* which is returned to the refinery. (2) By making

[3] THE MINERAL INDUSTRY, Vols. VIII. and X.

a short time, of course, sulphuric acid must be bought for addition to [illegible] electrolyte.

[illegible] ELECTROLYTIC COPPER REFINERIES IN EUROPE.

[illegible]	Name of Company and Location of Works.	Kind of Material usually Treated.	Approximate Daily Output in Tons of 2,240 lbs.	Number and Capacity of Tanks.	No. of Tanks in the Series.	Arrangement of Electrodes.
[illegible]	[illegible]	Gold and silver bearing bullion.	10 to 20	Eight @ 75 Kw.	[illegible]	Multiple.
	[illegible]	Gold and silver bearing bullion.	10 to 20	[illegible] Kw.	[illegible]	Multiple.
	[illegible]	Gold and silver bearing bullion.	10 to 20	Four @ 75 Kw.	[illegible]	Multiple.
	[illegible]	Gold and silver bearing bullion.	10 to 20 (capacity)	Four @ 150 Kw.	[illegible]	Electric.
	[illegible]	Gold and silver bearing bullion.	6 to 10			Multiple.
	[illegible]	[illegible]	20	Three @ 75 Kw.*	[illegible]	Multiple.
	[illegible]	[illegible] crude copper.	20	Two @ 0 Kw.*	[illegible]	Multiple.
	[illegible]	Gold and silver bearing bullion.	5			Multiple.
	[illegible]	Gold and silver bearing bullion.	5	[illegible] @ 0 Kw.*	[illegible]	Multiple.
	[illegible]		1			Multiple.
	[illegible]	Table bars.	10			Electric.
	[illegible]	[illegible] copper.	0 to 1			Multiple.
	[illegible]		[illegible]	[illegible] Kw.		Multiple.
	[illegible]		[illegible]	[illegible] Kw.		Multiple.
	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Kw.	[illegible]	Multiple.
	[illegible]	[illegible]	[illegible]	[illegible] Kw.	[illegible]	Multiple.
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Electric.
	[illegible]		[illegible]	[illegible] Kw.*	[illegible]	Multiple.
	[illegible]		[illegible]			Multiple.
	[illegible]		[illegible]	[illegible] Kw.*	[illegible]	Multiple.
	[illegible]	[illegible] copper.	[illegible]	[illegible] Kw.	[illegible]	Multiple.
	[illegible]		[illegible]		[illegible]	Multiple.

[illegible] of Newark, [illegible] W. [illegible], [illegible], [illegible], N. J., has patented [illegible] electrical [illegible] comprising [illegible].

* Electrical Review, N. Y., April 11, 1903.

bath and adapted to be lifted, a plurality of longitudinal shafts connected with this member and free to shift endwise, hooks connected with the shafts and adapted to engage electrodes, the arrangement being such that the hooks are free to engage the electrodes when the shaft is shifted endwise.

Electrolytic Dissolution of Copper Anodes.—Woolsey McA. Johnson[5] assumes that ordinary copper anodes may be considered as being mixtures of pure copper and copper-silver alloys, cuprous oxide, antimony oxide and arsenic oxide, or solutions of these alloys and oxides in pure copper, and states that, in his opinion, because the electrical resistance of copper-silver alloys and of the oxides is higher than that of pure copper, the silver alloy and oxides would tend to "slime," under normal conditions, and thus tend to keep the solution in a pure condition. To explain these views, which have been more or less well recognized since 1885, when Dr. Kiliani's pioneer investigations were published, Johnson has recourse to the following known facts: (1) Every metal has a certain specific electrolytic tension or voltage depending upon its temperature, physical condition and the solution in which it dips. (2) Every metal has a specific electrical conductivity. (3) These two properties are profoundly modified by alloying with other metals.

On these properties of the resulting alloys segregated in the anode, depends the selective electrochemical dissolution. Metals unite with one another to form alloys, in most cases with the evolution of heat, and the atoms are then united with a firmer bond. In other words the free energy is diminished, and as the electrolytic solution tension is measured by the free energy of the metal, in normal solution of its ions, it also must decrease. The resultant product is harder and has less tendency to dissolve. That most alloys of any two metals show a poorer conductivity than the mean conductivity of the metals composing such alloy, and in many cases, than the conductivity of either metal alone, is well known.

These facts have an important bearing in electrolytic refining, in determining the behavior of alloys and oxides contained in ordinary copper anodes. For instance, if it is considered that a particle of silver-copper be surrounded by pure copper crystals, the effect of the great difference in electrical conductivity is certain to shunt the current around this silver-copper alloy and finally dissolve its copper backing. It then can be brushed off into the slime. This, of course, applies to all the alloys (and oxides) that have a lower conductivity. Arsenic and antimony, if present as metals, have a greater tendency to dissolve than copper, because of their high electrolytic solution tension. Fortunately for the electrolytic refiner, however, the larger portion of these elements are thoroughly oxidized, either in the converter or reverberatory furnace. The copper is then brought to "set" in the refining furnace, before casting, if it is not cast direct from the receiver, mixer or converter. The heats of oxidation of arsenic or antimony being many times larger than that of copper, the oxides of the former metals are not reduced to any extent in the "poling" operation, as long as any cuprous oxide is left. These oxides are thus present in the anodes as insulators and as such pass into the slimes directly from "oxidized" anodes.

[5] Paper read before the American Electrochemical Society, Sept. 16, 1902.

COPPERAS

The largest producer of copperas is the American Steel & Wire Co., whose plants are operated in connection with the manufacture of wire at Worcester, Mass.; Cleveland, O.; Joliet, De Kalb and Waukegan, Ill. Among the other producers are the Pennsylvania Salt Mfg. Co., Natrona, Pa.; C. K. Williams & Co., Easton, Pa.; S. P. Wetherill & Co., Newcastle, Pa.; The Atlantic Dynamite Co., Dover, N. J.; The American Nickel Works, Camden, N. J.; Charles Lennig & Co., Philadelphia, Pa.; The American Tin Plate Co., Ellwood, Ind., and the Stauffer Chemical Co., of San Francisco, Cal. Shipments of natural copperas from Steubenville, O., where it is formed by atmospheric oxidation of pyrite, has been discontinued, as it was found to be unprofitable. The price of copperas at New York at the commencement of 1902 was about $8 per ton, against an average of $10 per ton for the previous year. The price early in 1903 was $9 per ton. These quotations are for carload lots, an additional $2 per ton being asked for lots of smaller size. There is no opportunity for export of copperas, for the reason that England, France and Germany also produce it as a by-product in larger quantities and at a lower cost than it can be manufactured in the United States.

PROGRESS IN ELECTROCHEMISTRY AND ELECTROMETALLURGY IN 1902

By [illegible]

Alkalies and Bleach.—In THE MINERAL INDUSTRY, Vol. X., the electrolytic alkali and bleach industry was described at considerable length and the two latest additions to the rank of industrial processes—the Acker fusion process and the "bell" gravity process—were illustrated and described. The most important event during the year 1902 was the failure of the negotiations for the renewal of the arrangement between the United Alkali Co., of Liverpool, and the Elektron Co., of Frankfort, regarding the output and price of bleaching powder in 1903. For the past three years these two firms, representing the chemical and electrolytic manufacturers, respectively, have maintained the price of bleaching powder in Europe at the comparatively high level of $28·80@$31·20 per ton. The failure to renew the agreement signifies that a period of open competition is now to be entered upon, and very large sales of bleaching powder for delivery over the entire year 1903 are reported to have been made at the low prices of $16·80@$18 per ton.

That some of the electrolytic alkali works will be heavily handicapped by the fall of nearly 50% in the selling value of the product upon which they have relied chiefly for profits is certain, and it is equally certain that some of the smaller and less well-equipped works will be compelled to suspend operations. In a recent series of articles[1] I have discussed at considerable length the present position of the electrolytic alkali industry, and have attempted to forecast its future in view of this fall in the price of bleaching powder. The following extracts summarize the position and prospects of the various processes and companies now in operation in Europe and America.

America.—The total power now available for the manufacture of caustic alkalies and bleaching powder by electrolytic methods is 11,500 H.P., and this will be increased at an early date to 14,000 H.P. On the assumption that the whole of the chlorine liberated by this process is absorbed in the manufacture of bleaching powder, we find that 40,000 tons and 49,000 tons are the present and prospective totals, respectively, manufactured by the American electrolytic alkali works. This is certainly a large proportion of the home consumption, and the striking growth of the new industry in America accounts for the considerable fall in the British exports of bleaching powder.

United Kingdom.—The total available power at Middlewich and Weston Point for the production of alkalies and chlorine products is now between 5,000 and 6,000 H.P. When the additions to the first-named works are completed over 7,000 H.P. will be devoted to the electrolytic decomposition of salt, which will equal an aggregate production of about 25,000 tons bleaching powder per annum.

Germany.—The maximum output of the group of works at Griesheim, Bitterfeld and Rheinfelden is stated to be 25,000 tons of caustic potash and 40,000 tons of bleaching powder per annum. The electrolytic works of the Solvay Co., at Osternienberg, add about 5,000 tons to the latter total. The home demand for bleaching powder is therefore more than met by the output of the electrolytic works.

France.—The position of the electrolytic industry in France is not encour-

[1] *Electrician*, Nov. 14, 28, and Dec. 12, 1902.

[illegible] works planned or actually erected, only one appears to be in regular operation for the production of caustic alkalies and bleaching powder, and [illegible] of this works (Lamotte) is not large. The greater portion of the [illegible] powder produced in France is still supplied by the old Leblanc works. [illegible] largely exceeds the home consumption, and one-third of the [illegible] exported.

[illegible] The position of the electrolytic alkali industry in Switzerland [illegible] than in France, and, although only two works have been [illegible] applying all the power available to the manufacture of caustic and [illegible] powder.

[illegible] Russia, Austria, Italy and Spain are all producing [illegible] alkali works, operating under more or less favorable conditions [illegible] and demand. In these outlying countries of Europe [illegible] of the industry may be expected, for hitherto they have drawn [illegible] caustic alkalies and bleaching powder, chiefly from France, [illegible] and the United Kingdom.

[illegible] statements of efficiency and costs which are given below [illegible] the most reliable figures for the various processes, and are re[illegible] as stated in the *Electrician* of Dec. 12, 1902.

[illegible] AND COMMERCIAL EFFICIENCIES OF THE VARIOUS ELECTROLYTIC ALKALI PROCESSES.

Process	H.P. Required per Ton of Alkali	Actual Yield in Grams per Amp.-Hour		per Kw.-Hour		Efficiencies Per Cent.	
		Theor.	Ct.	Theor.	Ct.	Chemical	Energy
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] figures, we find that to obtain 1 metric ton of 100% caustic [illegible] processes, the following numbers of H.P.-hours are required, [illegible] relative costs of power for the processes are as stated in [illegible]

[illegible] required to obtain 1 metric ton of 100% caustic soda [illegible] ELECTROLYTIC ALKALI PROCESSES WITH THE RELATIVE [illegible] POWER AT 0·75d. PER H.P.-HOUR.

Process	H.P.-hours per Ton	Cost of Power per Ton
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible] above results it must be remembered that the processes will [illegible] in various degrees [illegible] The [illegible] stated [illegible]

decomposing vessel attached to the cell, and thus, in the case of this proce no additional costs are entailed for evaporating the cell solutions.

ESTIMATE OF CHIEF ITEMS OF COST FOR PRODUCING 1 TON OF 72% CAUS SODA AND 2·1 TONS 35% BLEACHING POWDER BY TYPICAL WET AND DRY PROCESSES.

	Castner-Kellner.	Acker.
Power	£2 17 0	£4 19 4
Raw materials (salt and lime)	1 7 0	1 7 0
Fuel (for evaporating)	1 8 0	.....
Packages	1 10 0	1 10 0
Totals	£7 2 0	£7 16 4

The year 1902 in the electrolytic alkali industry has been marked by unwon freedom from patent litigation. The patent case referred to in THE MINE INDUSTRY, Vol. X., as pending between the Commercial Development Corpo tion and the Castner-Kellner Alkali Co. did not come into the courts. The planation of this may be found in the fact that the plaintiff company is in fin cial difficulties, and in November, 1902, the shareholders decided upon liquidati

Aluminum.—See the special article elsewhere in this volume.

Antimony.—Izart has described[2] an electrolytic process for obtaining a mony from its ores, which is reported to be working at Nakety, in New C donia. A diaphragm type of cell is used, with the antimony in solution as p sulphide. With an E.M.F. of 1·6 volts and a current density of 0·80 amp per sq. d.c.m. a current of 76% efficiency is said to be obtained. The Siem & Halske process is reported to be at work at Banya, in Hungary, and at Vien while a new process, of which no details are published, is stated to be in us Cassagna, in France.

Arsenic.—The Westman process[3] for extracting arsenic from arsenical was briefly referred to in THE MINERAL INDUSTRY, Vol. X. No further det relating to the operation of the process by the Arsenical Ore Reduction Co. Newark, N. J., have been published. The process has been criticized unfa ably by the *Electrical Times* (London), which points out that it would yield arsenic in the form of metal, not of oxide, and that this metal would be conta nated with zinc, sulphur and antimony, which are volatile at a red heat.

Barium Hydrate.—A wet method for producing barium hydrate from bar sulphide has been patented in Brussels and London, and an experimental p has been erected in the former city. The process depends upon the of a mixed solution of chlorides and sulphides as electrolyte in a diaphragm of cell. Barium hydrate separates at the cathode, and sulphur at the anode, former being separated from the electrolyte by a centrifugal machine. So fa attempts to introduce this process into England have not been successful. the Bradley & Jacob process, see under the section "Barytes," elsewhere in volume.)

Bullion Refining.—The Deutsche Gold- und Silberscheide Anstalt, of Fr fort, one of the pioneer firms in electrolytic refining, has increased its capit

[2] *L'Electricien*, July 19, 1902. [3] English Patent No. 17,987, 1902.

Copper.—The output and price of raw copper during 1902 have been dealt with at length in *The Engineering and Mining Journal,* 1903, and it is only necessary to point out here that the break in price which occurred 13 months ago, has caused serious financial loss to the electrolytic refineries, which had accumulated large stocks of ingot copper at the higher figure, or had delivery contracts running for ingot copper at the date of the collapse in value. The French and German Elmore companies appear to have been among the most unfortunate sufferers in this manner. Both companies have been obliged to report serious losses to their shareholders during 1902, whereas, if there had been no break in price, satisfactory dividends would have been paid. The continuance of the slump in price is also causing many of the new mining and smelting companies, floated during the boom, to cease operations, and my prophecy concerning these companies (see THE MINERAL INDUSTRY, Vol. X., p. 256) is rapidly being fulfilled. With regard to the work of the English Elmore Co., at Hunslet Leeds, the reorganized plant is now in operation, and according to the report presented to the shareholders in May, 1902, an output of 25 tons of tubes per week was being attained in the early part of the year. The maximum capacity of this plant is 60 tons per week. There is nothing new to report concerning the ordinary electrolytic refining process in Europe, and no figures of any value have been published during 1902 for the output of the electrolytic refineries in either France or the United Kingdom.

Danneel, in an article upon electrometallurgy in Germany,[8] gives the following figures for the production in that country: Norddeutsche (1900), 800 tons; Mansfelder Gewerkschaft (1900), 965 tons; Altenau, 220 tons; Niedermarsberg, 1,000 tons; Schladern, 1,200 tons. The total copper production of Germany is stated to have increased in the last ten years from 24,700 tons to 32,000 tons, but these figures evidently refer to crude copper and not to electrolytic copper. A new refinery is being erected by the Cape Copper Co., at Briton Ferry, Wales. The Dessolle method of depositing copper is in use at the small works of Levallois-Perret in France. This method depends upon the use of a jet for forcing the electrolyte against the surface of the cathode. The rapid circulation obtained in this manner enables a current density of 750 amperes (presumably per sq. d.c.m.) to be used, and a deposit 1 mm. in thickness can thus be obtained in 15 hours.[9] It is questionable whether this patent could be maintained either in the United Kingdom or in America, since in both countries, previous trials of this method have been made. With regard to the Hoepfner process for extracting copper from its ores, no new information is available for publication; presumably the Papenburg works are still operating this process. The Keith extraction process which was worked for a time at the mines of the Arlington Copper Co., New Jersey, has been very fully described by the inventor in a paper read during 1902. Financial difficulties are reported to have caused the temporary suspension of work at these mines. An illustrated description of the Raritan Copper Works, Perth Amboy, has been published in the paper named below.[11] This is practically a brief summary of the detailed description which was published in THE MINER-

[8] *Zeitschrift fuer Elektrochemie*, March 6, 1902.
[9] *L'Electrochemie*, November, 1902.
[10] Electrical Review, New York, March 22, 1902.
[11] Scientific American, March 15, 1902.

to the progress of the electrolytic bleaching industry. The fall of 1 in the price of bleaching powder in Europe, will for the time stop expansion in use of electrolytic bleach solutions, and possibly some of the plants already stalled may be compelled to cease operations. Foerster & Müller have publi details of laboratory investigations relating to the behavior of hypochl solutions on electrolysis.[16] A new form of electrolytic cell for producing h chlorites, has been patented, and is described in the paper named below.[17] this cell, a current of 50 amperes and 100 volts, is reported to produce 1 active Cl per hour. This cell is manufactured by the Fabrik Elektri Bleichapparate at Pfronten in Bavaria. Ahlin has patented an improved pr for bleaching wood-pulp, in which the exhausted hypochlorite liquors are e sified with air, and are again used for bleaching the pulp. Remarkable ef as regards the color of the bleached pulp,[18] are obtained, supposed to be d mechanically held oxygen.

Iron and Steel.—The direct production of iron and steel in the electric fu by heating the ores with the theoretically necessary weight of coke, has tinued to receive much attention throughout 1902, and a very large numb patents are being taken out in connection with this use of the electric cu The unsatisfactory position of the calcium carbide market, and the closing of a large number of the carbide works in Europe, has rendered it comparat easy for the inventors to obtain trial of their processes on an industrial scale in every country of Europe where such works are in existence, experimental of the electrometallurgical processes for iron and steel production are now t place. So far as the limits of space allow, the various patented processes are with below:—

The Conley Furnace.—In this furnace the reduction is effected by co of the ore and coke with transverse plates, placed in the throat of a coni shaped furnace. A current is passed through these plates sufficient to keep at a red heat, and the hearth of the furnace is further heated by an electr heated belt. It is estimated that for a Conley furnace of 100 tons pe capacity, 5,000 E.H.P. would be required, and that steel could be produced cost of $11·85 per ton. The patents for this process are owned by the El Furnace Co. of New York, and it is stated that the company is now engag erecting an 8,000-H.P. plant at Elizabethtown, N. Y. The Massena El Steel Co. with a capital of $500,000, has also been formed to erect and w similar plant at Massena.[19]

The Harmet Furnace.—The Harmet furnace consists of a smelting-fur a reduction furnace and a refining furnace, using both resistance and arc-hea The waste-gases from the reduction and refining divisions of the furnac utilized for heating the raw materials with which the furnace is fed. Acco to the inventor, 3,600 E.H.P. hours are required to produce 1 ton of steel estimated cost of $5·61.[20] The furnace is reported to be operating success at St. Etienne in France.

[16] *Zeitschrift fuer Elektrochemie*, Aug. 28 and Sept. 4, 1902.
[17] *Elektrochemische Zeitschrift*, October, 1902.
[18] *Papier Zeitung*, Vol. 26, 1901.
[19] *Electrochemist and Metallurgist*, March, 1902.
[20] *L'Electrochemie*, July, 1902.

Society.[25] Lead sulphide is used as cathode in an acid solution, and the redu tion occurs as the result of the action of nascent hydrogen upon the sulphi with the formation of spongy lead and hydrogen sulphide gas. The chief di culties met with in operating the process are due to incomplete reduction of t sulphide, and to the escapes of H_2S gas. Two pounds of lead are stated to obtained per E.H.P. hour. In August, 1902, a report was current in New Y that the company was in financial trouble; and possibly the difficulties refer to above have proved insurmountable. A new electrolytic process for treatm of lead bullion is reported by Titus Ulke to be in use at Trail, B. C.[26] The proc which has been patented by Anson G. Betts, is based on the solubility of lead an acid solution of lead fluosilicate. The E.M.F. required to deposit the l from this solution is only 0·2 volt; the slimes are worked up for gold and sil The works using this process are designed for the treatment of 10 tons l bullion per day, averaging 8,000 oz. gold and silver per ton.

Magnesium.—There is nothing new to report concerning the electrol method of producing magnesium from fused carnallite.

Molybdenum and Other Rare Metals.—In the United Kingdom a comp entitled the Tungsten & Rare Metals Co. has recently been floated with a capi of $96,000 to purchase and work patents granted to Steinhart & Vogel for production of rare metals. The methods by which these are to be obtained fr their ores, are presumably electrometallurgical in character; $22,560 has b paid for the patents and the supervision by the inventors for five years.

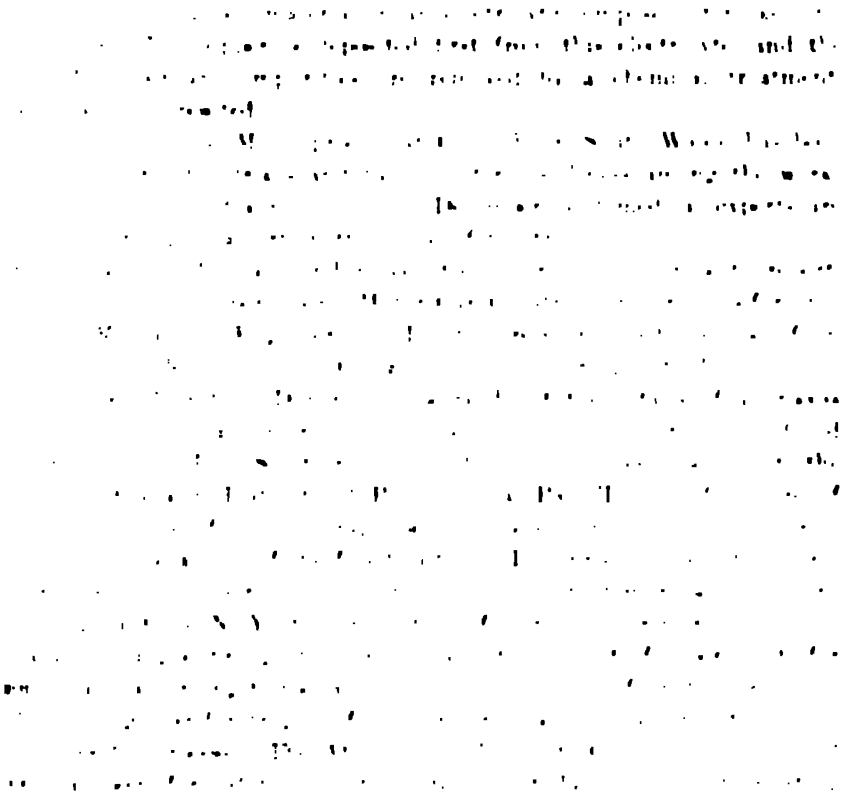
Nickel.—The chief event of 1902 with regard to the nickel mining and fining industry has been the formation of the International Nickel C with a capital of $24,000,000. This company has absorbed the Nickel Corp tion of London, and several other large companies interested in the metal, with the Rothschilds of Paris, this company now practically controls the wor output of nickel. The following figures have been published during 1902 the world production: 1899, 6,460 tons; 1900, 7,892 tons; 1901, 10,401 ton

As regards the progress of the Hoepfner process at Papenburg in Germ little fresh information has been published during 1902. Replying to st ments that the process was a failure, Dr. L. Hoepfner has published offi figures showing that in 1901, 150 tons nickel were produced at Papenburg, that in April, 1902, the output of the metal at this works amounted to 800 per day.[27]

The Frasch extraction process at Hamilton, Ontario, is reported to have fai and the same result is believed to have attended the trial of the Hoep process at this place.

The development of nickel mining properties in the Sudbury district Canada is proceeding rapidly, but the latest reports do not indicate that ei electrometallurgical or electrolytic methods of treatment are yet being u tor the ores obtained. The pure nickel ore from this district is to be sme with iron ore in ordinary blast furnaces at Saulte Sainte Marie. These furn *are now being erected.* The mixed ores of iron and copper are being sme

[25] *Electrical Times*, June 26, 1902. [26] Engineering and Mining Journal, Oct. 11, 1902.
[27] *Zeitschrift fuer* Elektrochemie, April 24, 1902.



1902. As regards the industrial application of these methods, there is nothing to add to the paragraph devoted to this subject in THE MINERAL INDUSTRY, Vol. X.

Oxygen and Hydrogen.—There is nothing new to report relating to the commercial production of these gases by the electrolysis of water, beyond the publication of a hand-book devoted solely to this branch of the electrochemical industry. The author is Dr. Victor Engelhardt, of Vienna, and his work forms the first of a projected series entitled, *Monographien ueber angewandte Elektrochemie*, by authors who may be regarded as experts in the various subjects dealt with.

Ozone.—The year 1902 has been marked by a distinct revival of interest in the applications of ozonized air for water purification and sterilization. At Lea Bridge, London, the East London Water Co. has been carrying out experiments with this method of water sterilization. No official results of these trials have yet been published. In Holland the noted chemist, Prof. Van't Hoff, has been devoting some attention to the subject, and has read a paper describing trials with the Vosmaer-Lebret ozonizer and process at Schiedam. These trials were satisfactory, and it is possible that the process may be tried on a larger scale at Rotterdam.[32] In Germany, Siemens & Halske has devoted much attention to the problem, and has erected small plants which are operating on a commercial basis at Schierstein and at Paderborn, two small towns in western Germany. Satisfactory results are stated to have been obtained. Illustrated descriptions of these two installations may be found in the paper named below.[33]

As regards the Marmier & Abraham ozonizer and process, full details of which have appeared in earlier volumes of THE MINERAL INDUSTRY, a small plant has been erected in the brewery of M. Velten, at Marseilles, using a voltage of 30,000; a concentration of 12 g. ozone per cubic meter of air, is obtained with a discharge equivalent to 5 K.W. per sq. m. of electrode surface.[34]

Sodium, Sodium Peroxide and Sodium Cyanide.—There is little to add to the information given in THE MINERAL INDUSTRY, Vol. X., relating to the electrolytic production of metallic sodium, or of its derivatives, sodium peroxide and sodium cyanide. The English, German and French firms engaged in this industry convert most of their sodium into the peroxide or the cyanide. At Niagara Falls, N. Y., according to Prof. Richards, the Niagara Electro-Chemical Co. is employing 1,000 H.P. in the manufacture, and is producing daily 6,250 lb. of metallic sodium.[35]

Swinburne, in the presidential address delivered early in December in London before the members of the Institution of Electrical Engineers, referred to the attempts that have been made to electrolyze fused sodium chloride, and to separate metallic sodium and chlorine from this salt. Though these experiments failed he is still hopeful concerning this process, and predicts that in a few years metallic sodium will be sold for a few dollars per ton. In this connection, Darling's process for electrolyzing fused sodium nitrate (see nitric acid), and the laboratory research carried out by Le Blanc & Brode on the chemistry of the Castner process,[36] are of interest.

[32] *Zeitschrift fuer Elektrochemie*, July 24, 1902.
[33] *Ibid.*, Nov. 27, 1902.
[34] Revue de Chimie Industrielle, August, 1902.
[35] Electrochemical Industry, September, 1902.
[36] *Zeitschrift fuer Elektrochemie*, Sept. 11 and 18, 1902.

ing.—There is nothing to add to the information contained in THE ... Journal, Vol. V., relating to the use of the electric current for ... purposes.

The electrolytic method of stripping tin from tin scrap and waste ... to be extending, and in a recently published memoir upon the subject[1] ... gives a list of eight factories in Germany and Austria, where the ... method is employed.

... consumption of tin scrap in Germany alone is said to reach 30,000 tons ... and as this is greater than the total production of the country, ... being imported from Switzerland and other countries. Mennicke ... uses sodium hydrate as electrolyte, and it is believed that this is the ... process used. At Manchester, England, trial has been made with ... Kemp's process, which is based upon the use of an electrolyte containing ... free chlorine and free from arsenic, and a small percentage of sulphuric ... acid. Some of waste cuttings are said to have been treated by this plant.[2] ... It has been stated the use of an electrolyte containing ammonium sulphate, ... sulphuric acid, but this process does not appear to have been worked on ... a large scale.[3]

... the electrolytic extraction of tin from ores or slags, Hargous has ... a process based on the use of a stannic chloride solution for leaching ... It is doubtful if this will be successful, since the difficulties that have ... the development of the Hoepfner process for extracting copper, will ... exist in this procedure. The Hulin-Frasch & Heroult process for the treatment ... of Tasmanian ... in Germany, has been referred to in previous reports, and ... the last concerning this process is that the plant at Tostedt is to be ...

... The ... industry has not made much progress during ... the ... of Hunter Wright & ... England where the ... process is employed, lead ... of zinc are said to have been obtained ... together with small ... of blue billy powder as a by- ... The ... output is reported to be 3 tons zinc and 2 tons lead ... The ... output of ... is reported to be used after ... for ... cartridge cases.

... The Siemens & Halske process (see THE JOURNAL, ... at Westfeld, Prussia, has ... long been in ... and ... the progress made ... process ... the ... of ...

... A Parkes process for the treatment of ... by the electro- ... has been ... which it was stated ... THE ... have not appeared to have met with much success. ...

[1] ... Elektrochemische und Metallurgische Industrie, 1904.
[2] ... Journal, Jan. 31, 1902, and ... No. 10, 1902.
[3] ... Elektrochemische Zeitschrift, April 30, 1902.

dustrial scale. An illustrated description of the furnace and details of its working will, however, be found in the journal named below.[41]

The Strozda process (see THE MINERAL INDUSTRY, Vol. X.) is reported to be in operation at two works in Germany. According to Danneel its success is doubtful. The electrolytic process introduced at Friedrichshütte for parting silver and zinc, has proved unsuccessful, and according to the same authority its use is to be dropped.

Borchers in a paper read before the general meeting of the "Verein" of German chemists in May, 1902, gave details of several electrolytic processes for extracting zinc from mixed ores and other materials now wasted. Blende carrying lead sulphide is charged into a revolving drum containing a dilute solution of sodium chloride, and chlorine gas is passed into the mixture. The sulphur separates in solid form, and the metals are converted into chlorides and pass into solution. The solution is freed from the insoluble gangue by filtrations and from impurities by chemical treatment; after concentration and fusion the mixed chlorides are electrolyzed. Zinc ores containing heavy spar as an impurity, can also be worked by this method. For zinc ores containing silicates Borchers recommends Dorsenmagen's procedure, which is based on reduction in an electric furnace with distillation of the zinc and formation of silicon carbide. This same procedure can also be applied to mixtures of iron and zinc sulphides, sufficient quartz being added to convert all the iron into ferrosilicon.

As regards electro-galvanizing, there is little that is new to report. Each country now possesses one or more of these works, but the electrolytic method does not extend rapidly, and its competition with the older dipping method is hardly felt. Paweck has patented the use of boric acid and borates in the galvanizing baths.[42] I am unable to say whether this addition is being employed in any of the electro-galvanizing works situated in France or other European countries.

[41] *Elektrochemische Zeitschrift*, December, 1902.

[42] French Patent No. 318,163, 1902.

FELDSPAR.

[illegible] of the production of feldspar in 1902 are not yet available, but [illegible] amounted to 31,010 long tons, valued at $220,122, as compared with [illegible] long tons, valued at $[illegible] in 1900, and 26,[illegible] tons ($[illegible]) in 1899. During 1902, veins of feldspar were worked in Connecticut, Maryland, New York and Pennsylvania.

For a more full account of the occurrence, mining and uses of feldspar, reference is made to the article by T. C. Hopkins in THE MINERAL INDUSTRY, XI.

PRODUCTION OF FELDSPAR (CRUDE AND GROUND) IN THE UNITED STATES IN 1901.

State	Crude		Ground	
	Quantity	Value	Quantity	Value
	Short Tons		Short Tons	
[illegible]	[illegible]	$[illegible]	[illegible]	$[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] OF FELDSPAR IN THE UNITED STATES IN [illegible]

State	[illegible]		[illegible]		[illegible]	
	Long Tons	Value	Long Tons	Value	Long Tons	Value
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] [illegible] [illegible] [

FLUORSPAR.

BY HENRY FISHER.

THE production of fluorspar in the United States continues to be derived chiefly from the mines in Crittenden, Caldwell and Livingston counties, Ky., and Hardin and Pope counties, Ill., and in 1902 the quantity produced was 27,127 short tons, valued at $143,520, as compared with 19,586 short tons, valued at $113,803 in 1901. The producers of fluorite were the Kentucky Fluor Spar Co., the Fluorspar Co., Western Kentucky Mining Co., and Lucile Mining Co., all of Marion, Ky.; the Eagle Fluorspar Co., at Salem, Ky., the Rosiclaire Lead & Fluorspar Mines at Rosiclaire, Ill., and the Tennessee Fluor Spar Co., at Nashville, Tenn. Early in 1902, the Kentucky Fluor Spar Co., which has been the chief producer of fluorspar in recent years, absorbed The Fluorspar Co., and is now by far the largest producer in Kentucky. This company and the Rosiclaire Lead & Fluorspar Mines produced nearly 80% of the total output during 1902.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES. (IN SHORT TONS.)

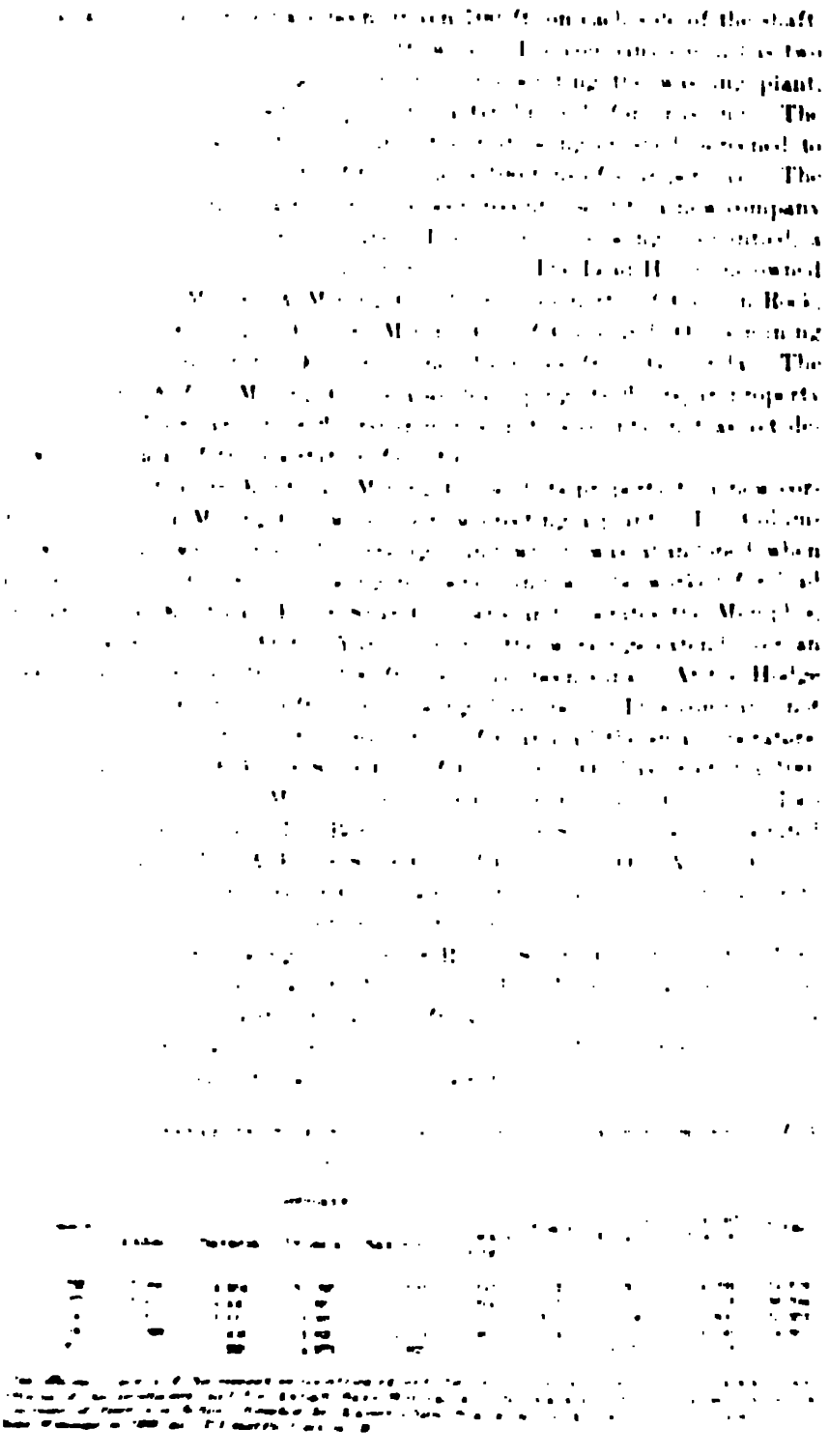
Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton
1891....	6,320	$38,000	$6·00	1895.....	4,000	$24,000	$6·00	1899.....	24,030	$152,655	$6·35
1892....	9,000	54,000	6·00	1896.....	6,000	48,000	8·00	1900.....	21,656	113,430	5·24
1893....	9,700	63,050	6·50	1897.....	4,379	30,264	7·65	1901.....	19,586	113,803	5·81
1894....	6,400	38,400	6·00	1898	12,145	86,985	7·16	1902.....	27,127	143,520	5·29

For the American market fluorspar is divided into six grades, namely, American lump No. 1, American lump No. 2, gravel, crushed, ground fine, and ground extra fine. The foreign product appears in two grades only—lump and fine.

The prices for fluorspar per short ton during 1902 did not change throughout the year, and were as follows: American lump, first grade, $14·40; second grade, $13·90; gravel and crushed, first grade, $13·40; second grade, $12·40; ground, first grade, $17·90; second grade, $16·50. The prices of the foreign fluorspar were: lump, $8@$12; ground, $11·50@$14. The average value of fluorspar per short ton, f. o. b. at mines, was: lump, $5; gravel, $4.

Arizona.—The fluorspar mined at Castle Dome, Yuma County, is being shipped to California, where it is used in the manufacture of Portland cement.

Illinois.—Golconda, on the Ohio River, is the shipping point of the southern Illinois fluorspar fields. The Illinois Central Railroad now extends from Golconda to Reevesville, and will help the development of the mineral resources of both Pope and Hardin counties. The Rosiclaire mine, at Rosiclaire, operated by the Rosiclaire Lead & Fluorspar Mines has attained a depth of 300 ft. in the main shaft, and has four levels, the first at a depth of 100 ft. and the other



The Use of Sodium Fluoride for the Purification of Water.

By Charles A. Doremus.

Mechanical filtration of water was first applied on a large scale during the summer of 1888. Later in that year attempts were made near New York to use caustic alkali to soften water, but with very unsatisfactory results; and numerous tests were made with various chemicals to precipitate the lime and magnesia contained in the waters in common use, sodium fluoride being finally selected. This salt, however, could not be purchased, so that when in May, 1889, a patent for its use as a precipitant for lime and magnesia in water was granted in the United States and in Europe, the question of getting a supply of the salt became a serious one. It was thought that a cheap and abundant supply could be easily obtained from cryolite, a compound consisting of 51% NaF, the sale of which in the United States was in the hands of the Pennsylvania Salt Manufacturing Co. This company manufactured, at its works at Natrona, Pa., the first large quantity used in this country, but the price was excessive and the sodium fluoride had to be obtained elsewhere, chiefly from fluorspar and soda ash.

Repeated attempts have been made to find a simple method to cheapen the manufacture of this article. In 1900 I patented a method which consists in treating the cryolite with superheated steam. The fluorine of the cryolite is liberated as hydrofluoric acid, while the residue consists of sodium aluminate, a commercial product. Thus the cryolite in its entirety is rendered useful. The small quantity of impurities—iron, lead, etc.—is left as a residue on leaching out the sodium aluminate. The small proportion of silica is evolved as hydrofluosilicic acid, or it can be removed by one of the several methods in common use. Experiments with this process on a large scale have not been a commercial success.

The chief use of sodium fluoride is to prevent incrustations in steam boilers. The precipitated calcium and magnesium fluorides form a non-adherent sludge which is easily blown out, and as the calcium or magnesium salts present react to form fluorides, the grains per gallon of calcium and of magnesium need only be known in order to calculate the weight of sodium fluoride necessary to precipitate them. If water is to be softened, the chemically equivalent proportion of sodium fluoride must be added, but in practice one-quarter of the theoretical quantity will prevent incrustation, the physical properties of the sludge preventing the precipitated calcium and magnesium salts from adhering to the sides of the boiler.

FULLERS EARTH.

By Henry Pohlen

[illegible] fullers earth in the United States during 1902 was 14,100 [illegible] short tons, as compared with 14,112 short tons, valued at [illegible]. The greater part of the product continues to be supplied from [illegible]. The balance being obtained from the mines in Arkansas, [illegible], Georgia, and New York.

The [illegible] of fullers earth in 1902 was 14,511 long tons valued [illegible] 14,700 long tons valued at $[illegible] in 1901 [illegible]. The consumption of English fullers earth during 1902 [illegible] has been for a number of years the demand for the earth [illegible] throughout the year. It has been used in preference to the [illegible] fact that [illegible] during [illegible] and two per [illegible] during [illegible]

[illegible] Arkansas Fullers Earth [illegible] and [illegible] has [illegible] and [illegible] the [illegible].

[illegible] T. W. Vaughan [illegible] Florida [illegible] Florida [illegible] Alabama [illegible] Georgia [illegible] Florida [illegible] Georgia [illegible] Florida [illegible] Georgia [illegible] Florida

Two samples analyzed showed SiO_2, 55·90% (57·26%); Al_2O_3, 12·40% (18·33%); Fe_2O_3, 2·40% (1·87%); CaO, 1% (2·58%); MgO, 8·12% (1·06%); H_2O, 10·50% (9·40%); and moisture, 9·40% (9%). Deposits of fullers earth occur also in this county near Sears, Wolffs and Withlacooche creeks.

France.—In 1901, France produced 3,400 metric tons of fullers earth, valued at $3,400, as compared with 3,700 metric tons, valued at $3,580 in 1900. The output in 1901 was obtained near Louviers in the Department of Eure.

Turkey.—Fullers earth is quarried on a large scale in Turkey, the deposits extending over 60 miles in length. The mines are located mainly in the caza of Eskichehir in the Kutahia district, between the Poursaktchai and the Sakaria Rivers. In the caza of Killis there is a mine which has been in operation many years, the product being exported to all parts of Syria and Anatolia.

TECHNOLOGY.

In his paper[2] entitled Experiments on the Diffusion of Crude Petroleum through Fullers Earth, Dr. D. T. Day reviews a series of experiments, which he has carried on during the past five years, on the changes which take place when crude oils are diffused through various substances. Quartz sand, amorphous silica and powdered limestone exhibit practically no selective action. Different clays show greatly differing capacities for separating the oils; the greatest effectiveness being secured as the clay approaches fullers earth in composition and texture. When crude petroleum was allowed to pass through finely powdered fullers earth, it became separated into a series of oils differing in color and specific gravity from the original product. The fractions varied in color from dark brown to clear white, and the specific gravity from 0·70 to 0·85. The differences in the resulting products are entirely physical, no chemical changes whatever taking place during the process of diffusion.

[2] Read at the meeting of the Geological Society of Washington, April 22, 1908: abstract in *Science*, June 26, 1908, p. 1007.

GARNET.

[illegible] of garnet for abrasive purposes in the United States during [illegible] 3,733 short tons, valued at $88,270, as compared with 4,444 [illegible] at $130,100 in 1901. The output was derived mainly from [illegible] in the vicinity of Tuxedo, N. Y. The prices for garnet remained [illegible] throughout the year, being $25@$35 per short ton, according to [illegible]. In New York there were no new developments during 1902, the output [illegible] for abrasive purposes in the North Creek section being but slightly [illegible] that of 1901. H. H. Barton & Sons, of Philadelphia, Pa., continue [illegible] to supply of garnet for its sandpaper factory in Philadelphia [illegible] mine located on Gore Mountain. The North River Garnet Co. [illegible] concentrates during the summer months enough garnet to supply the [illegible] for the [illegible] mineral of the other large sandpaper manufacturers [illegible] the [illegible] operations at Lawrence County by the Cornwall Land [illegible] consist mainly of quartz containing very small pink [illegible] and Adirondack mineral. This company has erected [illegible] plant and is trying to establish a market for its product. The [illegible] a considerable percentage of quartz [illegible] geological character of the Adirondack deposits and the [illegible] of the mineral product are given in THE MINERAL INDUSTRY [illegible]

GEMS AND PRECIOUS STONES.

By Joseph Struthers and Henry Fisher.

The value of the precious stones produced in the United States in 190 $318,300, as compared with $289,050 in 1901. Of the total, the value c sapphires and turquoises produced aggregated $245,000. In 1902, the in were as follows: uncut diamonds, $8,230,735; cut diamonds, $13,852,949; uncut precious stones, $52,025, and other cut precious stones, including n pearls, $4,641,339; a total of $26,777,048.

The following table gives the value of the production of precious sto the United States, according to Mr. George F. Kunz:—

Variety.	1901.	1902.	Variety.	1901.	
Agate	$1,000	$1,000	Peridot	$500	
Agate (moss)	500	500	Pyrite	3,000	
Amazon stone	200	500	Quartz, crystal	10,000	
Amethyst	500	2,000	Quartz, gold	2,000	
Anthracite ornaments	2,000	2,000	Quartz, rose	150	
Arrow points	500	.....	Quartz, rutilated	50	
Beryl (aquamarine, etc.)	5,000	4,000	Quartz, smoky	1,000	
Catlinite (pipestone)	2,000	2,000	Quartz, tourmalinated	1,000	....
Chlorastrolite	3,000	4,000	Rhodolite	21,000	
Chrysoprase	1,500	10,000	Ruby	500	....
Diamond	100	.....	Sapphire	90,000	1
Emerald	1,000	1,000	Silicified wood	7,000	
Fossil coral	100	.....	Tourmaline	15,000	
Garnet (almandite)	100	.....	Turquoise	118,000	1
Garnet (pyrope)	1,000	1,000	Utahlite (variscite)	250	....
Malachite	100	.....			
Mesolite (thomsonite)	1,000	1,000	Total	$289,050	$1

Diamonds.—*United States.*[1]—There were no diamonds found during as compared with an output valued at $100 in 1901. There was, howe diamond discovered in a meteorite from Cañon Diablo, at the foot of (Mountain, Ariz. The stone is of irregular shape and so hard that whe tempts were made to cleave and to polish it, two chisels were broken a emery wheel ruined.

South Africa.—The report of the De Beers Consolidated Mines, Ltd., fc fiscal year ending June 30, 1902, shows that the value of the diamonds amounted to £4,687,194. After deducting expenditures of £2,524,485, the balance for the year was £2,162,709. The balance brought forward fron previous year amounted to £1,277,342, which, added to the profit balance, tog with interest and revenue from various sources, increased the balanc

[1] *The diamond* deposits in the United States were fully described by William H. Hobbs in The M *Industry, Vol. IX.*, pp. 301-304.

From the amount dividends and bonuses amounting to £2,165,000, [illegible] remuneration of £116,594 were paid, leaving a balance of [illegible] carried forward. The output of blue ground was 1,117,641 loads, [illegible] about tons. 3,734,241 loads were washed, yielding 2,025,224 [illegible] There were also 1,151,816 loads of tailings treated, yielding [illegible] carats, and 18,778 carats of diamonds were recovered from [illegible] The average yield per load of blue ground and lumps from the [illegible] A monthly return for the fiscal year was 0·76 carat, at an average [illegible] per carat. The average yield per load for the Premier mine [illegible] was 0·71 carat, valued at 18s 7d per carat. The average yield from [illegible] was 0·21 carat, valued at 18s 6d per carat. At the [illegible] 6,916 loads of debris were washed producing 218 carats of [illegible] diamond weighing 69·5 carats was found in the Premier mine, but [illegible] of no regular shape will be cut down to about 30 carats. Its value [illegible] to be £15,000. The stock of blue ground and lumps on the floors of [illegible] and Kimberley mines at the end of the fiscal year was 2,630,040 [illegible] at the Premier mine 1,271,911 loads, and at Rustfontein mine, 180,934 [illegible] operations at the mines were hindered by the war and the resultant difficulty [illegible] of getting native coal and supplies. The report of the Kamfersdam Mines, [illegible] the year ending June 30, 1902, states that 512,000 loads of blue and yellow [illegible] were treated and washed, yielding 51,852 carats of diamonds. The dia[illegible] were sold for £40,511, and the stock on hand was valued at £24,345. The [illegible] was £64,741, and expenditure £58,405, leaving a balance of £6,336, [illegible] the balance brought forward from the previous fiscal year, makes [illegible] balance on hand £17,441. The Orange Free State & Transvaal [illegible] Mines, Limited, for the year ending the 31st December, [illegible] and [illegible] mines of £11,151. [illegible] was [illegible] to £11,151, and [illegible] also a [illegible] ground wash for washing. The Jagersfontein Mining [illegible] at between May 12 and the 31st December [illegible] loads of [illegible] and 10,762 carats of diamonds were sold at £11,112, obtained [illegible] the diamonds was £10,211, leaving a profit of £1,901 [illegible] account at the end of the year showed a balance of £11,441 [illegible] for the year ending 31st December, [illegible] Mines, Limited, was [illegible] at £1,941 [illegible] The [illegible] carat [illegible] carats [illegible] at £1,212. [illegible] were valued [illegible] with [illegible] have [illegible] were [illegible] These diamonds have been found at the [illegible] parcels of the diamond [illegible]

E. F. Heneage in a paper read before the Institution of Mining and Metallurgy, Nov. 20, 1902.

An article on diamond mining at Kimberley appeared in *The Engineer*, Jan. 16, 1903, p. 59, and Jan. 30, 1903, p. 115.

These deposits are also described by G. F. Williams in his valuable book on *The Diamond Mines of South Africa*, The Macmillan Co., 1902.

Australasia.—The output of diamonds in New South Wales in 1902 is estimated at 11,995 carats, valued at £11,326, as compared with 9,322 carats, valued at £9,756 in 1901. The diamonds were chiefly obtained from the Boggy Camp in the Copeton district, the mines in operation being the Star of the South, Malacca, and Elliott's mine. Diamonds were also found by prospectors while searching for stream tin. In October, 1902, the Monte Cristo mine, in the Bingara division, resumed operations after a long period of idleness. The Inverell Diamond Field Co., Ltd., operating on an alluvial deposit which yields per load 1·25 carats of diamonds, valued at 28s., and tin worth 8 to 9s., is in financial trouble, and the future policy of the company is still unsettled. The Soldier's Hill Diamond & Tin Mining Co., having exhausted its mine, has removed the plant to a prospecting area at Staggy Creek. During 1901, a few diamonds were found in an alluvial deposit near the Abercrombie River in the Cowra district, of which some were reported to be of a high value. The Australia Diamond Mining Proprietary Co. was engaged in removing its plant, and did no mining during 1901.

Brazil.—The Brazilian Diamond & Exploration Co., Ltd., capitalized at £225,000, obtained in September, 1902, the privilege of operating for a period of 90 years in the Republic of Brazil. Two-thirds of its capital must be raised within two years from the date of the privilege.

According to H. W. Furniss, the State divides the diamond region into 14 districts: Lençoes, Andarahy, Chique Chique, Santa Isabel, Cravada, Lavrinha, Campestre, Morro do Chapero, Bom Jesus, S. Ignacio, Chapada Velha, Paraguaçu, Sincorá and Cannavieiras, each region taking the name of the town near its center. Geologically there are but two sections, one in the central portion of the State along the Paraguaçu River, and the other in the southern part along the Pardo River. The Paraguaçu region is about 172 miles long and from 3 to 16 miles wide, the most productive area being in the foothills to the southeast of Serra das Lavras Diamantinas. The original rock is granite, frequently broken by gullies and crevasses. Sandstone and a conglomerate composed of round water-washed pebbles and a very hard matrix occur with the granite, and in these diamonds are found. The diamond-bearing material is called "cascalho." One method of mining is by removing the surface disintegration, or mining by tunnels between the boulders into the pockets in the deposit and taking out the cascalho. The cascalho is collected for a week, when it is washed, either by pouring it into ditches of running water and agitating it with a hoe, or by washing small quantities in large wooden basins. In the former case, arrangements are made to catch the heavy mass containing the diamonds, which is then washed in large wooden basins, the rock being hand picked. Another method of mining, carried on mostly on the Paraguaçu River, consists in diving to the bottom of the river and removing the silt till the underlying layer of clay

India.—Very little is being done in the diamond industry in India. Workin are still carried on by the Madras Diamond Co. at Vajrakarur, but this compa made no output during 1902, nor did the Bundelkhand alluvial mines of Centr India produce any diamonds.

Dr. Albert Ludwig[2] showed that diamonds could be obtained by subjecti carbon to strong gaseous pressure (pressures to 3,100 atmospheres being use at a low temperature in the presence of iron, or at the melting point of carb without using such a contact agent. For the purpose, he imbedded an ir spiral in powdered retort carbon and raised it to a red heat in an atmosphere hydrogen by means of the electric current.

M. Chaumet[3] has discovered that a close relationship exists between t fluorescent property and the brilliancy of diamonds under artificial light, esp cially candle light, which brings out the quality of the stone. Diamonds whi are non-fluorescent when exposed to violet light, become violet themselves, t brilliant stones showing a fluorescence of a very luminous and clear blue.

Technology.—A patent has been granted to F. E. Hilliard[4] for a machine f grinding and polishing gems, which consists of a standard, adjustable bo vertically and horizontally, which carries a screwed shaft-support capable being revolved about the standard and fixed in any position and at any desir angle. Adjustment pins on the side regulate a pointer on a scale or small di at the top of the machine, showing the exact inclination at which the stone held by the shaft. It is claimed that it is possible so to adjust the position of stone that a series of facets, four, eight or more, may be cut on a piece of ge material at any given angle, and each angle and facet be mathematically syr metrical.

EMERALDS.—There was no change in the value of emeralds produced in t United States during 1902, the outputs in 1901 and 1902 being valued at $1,0 each. The Colombian Government during 1901 offered for sale or lease t emerald mines of Muzo and Coscuez. These mines have been worked contin ously for more than three centuries. The annual output is not reported by t companies working the mines. The Somondoco Emerald, Ltd., owning mines Columbia, in its report for the year ending June 30, 1902, states that its oper tions were hindered by the revolution. Its expenditures during the year amount to £2,436, and the emeralds on hand were valued at £500. Emeralds are al mined near Minne, Norway, although no statistics of production are obtainable.

OPALS.—The production of opals in New South Wales in 1902 was valued £140,000, as compared with £120,000 in 1901. About 1,100 miners were e ployed during 1902. Operations were carried on with extreme difficulty account of the severe drought, which lasted until the month of Novemb Several fine specimens were found at White Cliff during 1902; one specim weighed 17 oz., and another weighing 13 lb. was a solid mass of gems. O part of this specimen, estimated to weigh 22 oz. is brilliant, and after bei polished, will be the finest opal extant. There was only a slight decrease the value of the opals produced in Queensland in 1902, although the conditio

[2] *Chemical News*, LXXXVII., Jan. 1, 1903. [3] *Comptes rendus*, 134, (20), pp. 1139-1140.
[4] United States Patent No. 701,879, June 10, 1902.

lead and the creation of a new coast. The largest stone found by this company weighed 9 carats. The stones are sent to New York and London to be cut. The American Gem Mining Co. produced about 50,000 carats of sapphires in 1901, which were cut by lapidaries in Helena, Mont. The Northwest Sapphire Co., of Butte, Mont., is mining sapphires on the Dry Cottonwood placers in Deer Lodge County, Mont., by means of a hydraulic. Stones of various colors are found in the gravel. It is reported that sapphires have been found near Cullinge Well, Ariz.

In 1901, the Burma Ruby Mining Co., Ltd., India, produced 9,786 carats of sapphires ($3,768), as compared with 7,239 carats in 1900.

The production of sapphires in Queensland in 1902 was valued at £5,000, as compared with £6,000 in 1901. During 1902, the drought in the Anakie fields retarded the industry, which was further hindered by the low prices obtained for the sapphires. The surface workings are being exhausted, and the deeper ones will soon have to be worked.

According to R. Dunstan the sapphires from Anakie, Queensland, have certain peculiarities in color, being either parti-colored or of a very deep and non-pasty blue, which by artificial light appears almost black, a characteristic which [illegible] from sapphires found in other parts of the world. The [illegible] and yellow shades which are also found in this field have no [illegible] [illegible] Sunny Corner, Sleepy Station, [illegible] [illegible] In some cases the [illegible] [illegible] [illegible]

[illegible] bought the Gail Lewis tourmaline mines at Mesa Grande, [illegible] Cal. The company is also establishing a cutting and polishing [illegible] The deposit of chrysoprase in Tulare County, Cal., is [illegible] and a new deposit of this stone has been discovered near Sugar [illegible] another deposit has been located at Buncombe County, N. C. An [illegible] has been opened in South Carolina, and two new deposits have [illegible] Virginia.

GOLD AND SILVER.

BY JOSEPH STRUTHERS, D. H. NEWLAND AND HENRY FISHER.

THE production of gold in the world during 1902 was 14,414,186 fine oz., valued at $297,960,910, as compared with 12,606,183 fine oz., valued at $260,877,429 in 1901. This increase was due chiefly to the United States, Mexico, Rhodesia, Australasia, and the Transvaal.

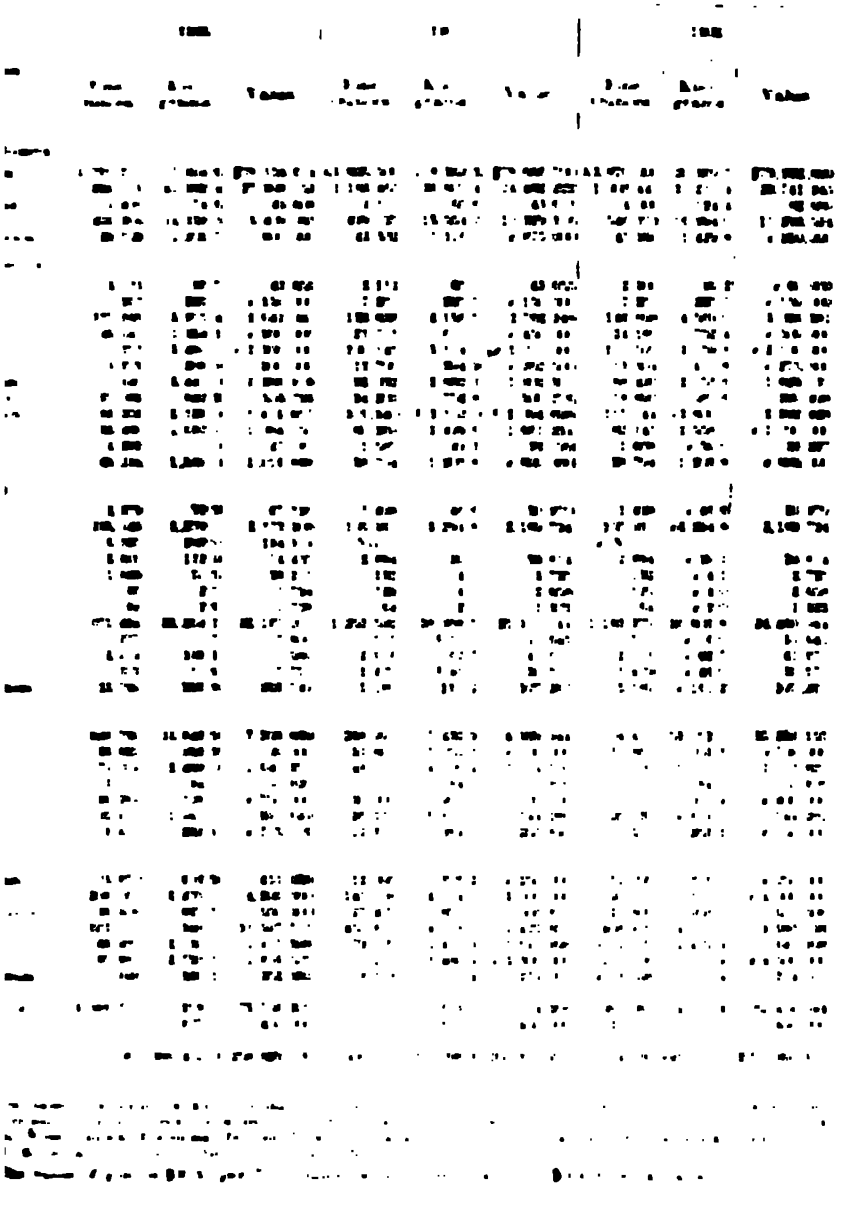
During the year 1902 the United States was passed by Australasia, which now occupies the foremost position as a gold-producing country, followed by the United States, Transvaal and Russia, in the order named. These four countries produced in the aggregate about 75% of the total world's production of gold in 1902. The largest individual increase in gold output was in the Transvaal, amounting to 1,465,419 oz., valued at $30,310,211, due to the declaration of peace and the resumption of work in the mines. Should the production of gold in the Transvaal continue to increase at this rate, it will require but a year or two for it to attain the record output of the year 1898.

PRODUCTION OF GOLD IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces. (c)	Value. (a)
Alaska	247,944	$5,125,000	364,385	$7,531,835	333,096	$6,885,700	403,730	$8,345,099
Arizona	124,577	2,575,000	131,884	2,725,000	197,515	4,083,000	198,933	4,111,945
California	730,527	15,100,000	757,136	15,650,000	817,121	16,891,400	812,319	16,790,634
Colorado	1,282,471	26,508,675	1,391,486	28,762,036	1,339,673	27,693,500	1,377,175	28,466,207
Idaho	84,664	1,750,000	100,000	2,067,000	90,427	1,869,300	71,352	1,474,846
Montana	233,147	4,819,157	249,153	5,150,000	229,495	4,744,100	211,571	4,373,173
Nevada	107,644	2,225,000	97,910	2,023,803	143,374	2,963,800	140,059	2,895,020
New Mexico	24,190	500,000	36,284	750,000	33,302	688,400	25,693	531,074
Oregon	62,893	1,300,000	79,342	1,640,000	87,950	1,818,100	87,881	1,816,500
South Dakota	282,944	5,848,464	320,513	6,625,000	313,446	6,479,500	336,952	6,964,798
Southern States (b)	8,466	175,000	11,127	230,000	11,402	235,700	15,404	318,400
Utah	166,909	3,450,000	200,296	4,140,000	178,513	3,690,200	173,886	3,594,224
Washington	32,656	675,000	38,703	800,000	28,082	580,500	13,166	272,141
Other States	2,164	44,725	3,145	65,000	2,104	43,500	1,879	38,839
Total domestic	3,391,196	$70,096,021	3,781,310	$78,159,674	3,805,500	$78,666,700	3,870,000	$79,992,800
Foreign	1,423,449	29,422,691	1,948,519	40,275,888	1,730,856	35,776,794	1,689,991	34,932,211
Grand total	4,814,645	99,518,712	5,729,829	118,435,562	5,536,356	114,443,494	5,559,991	114,925,011
Total domestic—kg	105,471	.....	117,611	.....	118,363	.....	120,369	.....
Total foreign—kg	44,274	.....	60,605	.....	53,835	.....	52,564	.....
Grand total—kg	149,745	.....	178,216	.....	172,198	.....	172,933	.....

(a) 1 oz. gold = $20·67; 1 kg. = $664·60. (b) Virginia, South Carolina, North Carolina, Georgia, Alabama and Texas. (c) Estimate furnished by Mr. G. E. Roberts, Director of the United States Mint.

GOLD PRODUCTION OF THE WORLD



PRODUCTION OF SILVER IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Troy Ounces.	Commercial Value (a)	Troy Ounces.	Commercial Value. (a)	Troy Ounces. (b)	Commercial Value. (a)	Troy Ounces. (b)	Com V
Alaska	150,000	$99,370	200,000	$122,660	47,900	$28,237	92,000	
Arizona	2,000,000	1,191,600	1,750,000	1,073,275	2,812,400	1,657,910	3,043,100	
California	600,000	357,480	1,170,902	718,114	925,600	545,641	900,800	
Colorado	23,114,668	13,771,781	20,336,712	12,472,500	18,437,800	10,869,068	15,676,000	
Idaho	4,800,000	2,859,840	6,100,000	3,741,130	5,542,900	3,267,540	5,854,800	
Michigan	.....	.....	.....	.....	81,000	47,750	110,800	
Montana	16,850,755	10,039,680	17,800,000	10,910,090	13,131,700	7,741,137	13,943,800	
Nevada	575,000	342,585	1,300,000	797,290	1,812,500	1,068,469	3,746,200	
New Mexico	550,000	327,690	550,000	337,315	563,400	332,124	457,200	
Oregon	140,000	83,412	150,000	91,995	160,100	94,379	93,300	
South Dakota	350 000	208,530	210,000	128,798	78,000	45,981	340,000	
Texas	450,000	268,110	525,000	321,983	472,400	278,580	446,200	
Utah	7,183,107	4,279,695	9,569,183	5,868,780	10,760,800	6,343,492	10,831,700	
Washington	300,000	178,740	300,000	183,990	344,400	203,023	619,000	
Others	63,284	37,705	100,000	61,330	43,100	25,408	45,100	
Totals	57,126,834	$34,086,168	59,561,797	$36,529,250	55,214,000	$32,458,653	55,500,000	$

(a) The average value in 1899, 59·58c.; in 1900, 61·33c.; in 1901, 58·95c., and in 1902, 58·16c. (b) furnished by Mr. George E. Roberts, Director of the United States Mint.

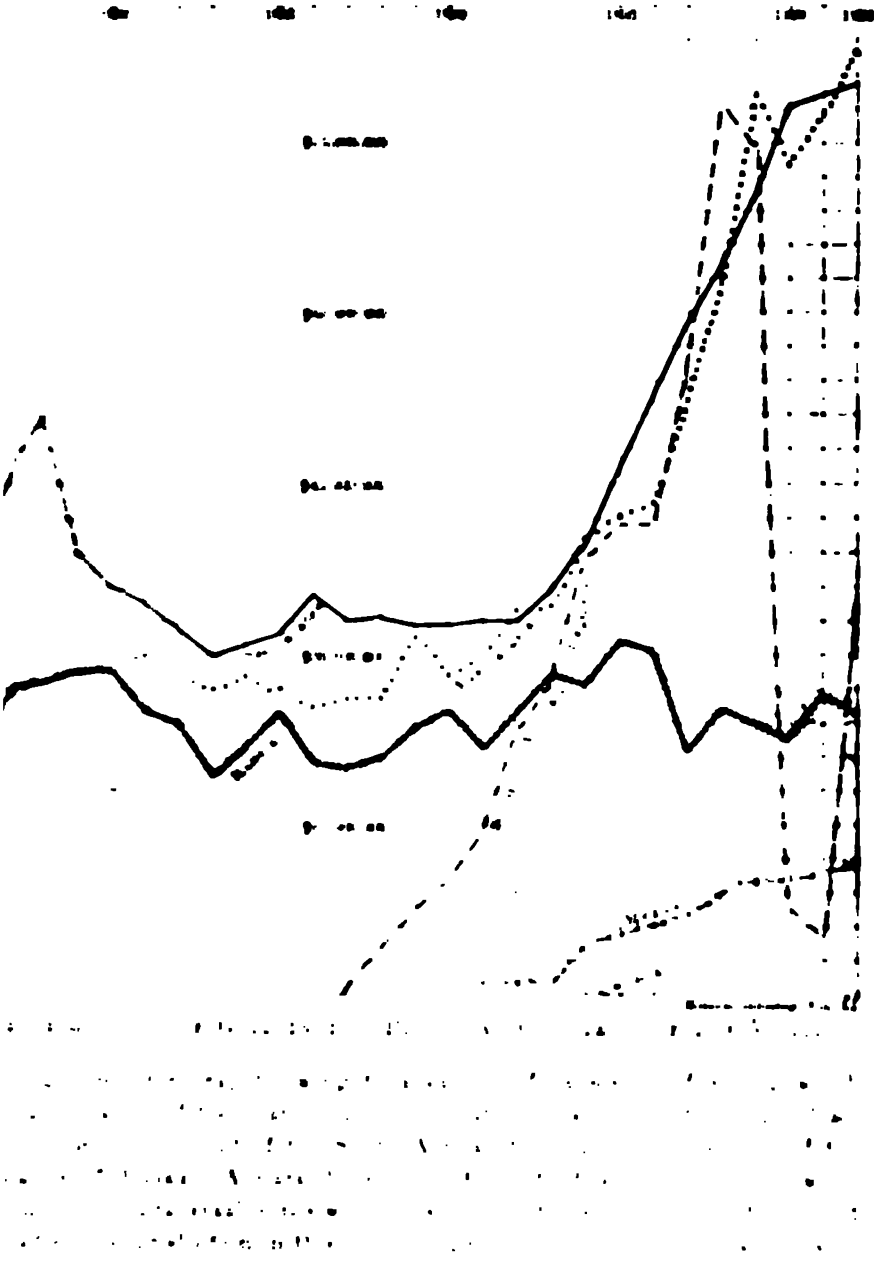
SILVER PRODUCTION OF THE WORLD.

Countries.	1901.			1902.		
	Troy Ounces.	Kilograms.	Commercial Value.	Troy Ounces.	Kilograms.	Com V
AMERICA, NORTH:						
United States	55,214,000	1,717,333·8	$32,458,653	*f* 55,500,000	1,726,229·4	$
Canada	5,539,199	172,287·0	3,265,356	4,372,986	136,014·0	
Mexico (a)	55,152,340	1,715,416·0	22,512,304	57,982,335	1,803,438·0	
Central America	1,072,095	33,345·6	632,000	*e* 1,200,000	37,323·9	
AMERICA, SOUTH:						
Argentina	*e* 150,000	4,665·4	88,425	*e* 150,000	4.665·4	
Bolivia	9,439,294	293,592·4	5,564,464	*b* 7,500,000	233,274·2	
Chile	2,199,003	68,365·0	1,296,312	*b* 1,650,000	51,329·3	
Colombia	2,520,000	78,380·1	1,485,540	*e* 2,520,000	78,380·1	
Ecuador	84,818	2,638·1	50,000	*e* 50,000	1,555·2	
Peru (a)	4,276,083	133,000·0	2,520,749	4,276,083	*e* 133,000·0	
EUROPE:						
Austria	1,351,950	40,205·0	762,005	1,351,950	*e* 40,205·0	
Hungary	727,770	22,636·0	429,020	727,770	*e* 22,636·0	
France	384,076	*g* 11,946·0	226,413	384,076	*e* 11,946·0	
Germany (c)	5,522,802	171,777·0	3,255,689	5,522,802	*e* 171,777·0	
Greece	1,100,754	34,237·0	648,894	1,100,754	*e* 34,237·0	
Italy	1,043,750	32,464·0	615,290	1,043,750	*e* 32,464·0	
Norway	147,895	*e* 4,600·0	87,184	147,895	*e* 4,600·0	
Russia	157,058	4,885·0	92,585	146,898	4,569·0	
Spain	5,947,935	185,000·0	3,506,305	5,947,935	*e* 185,000·0	
Sweden	50,059	1,557·0	29,510	50,059	*e* 1,557·0	
Turkey	480,400	*g* 14,942·0	283,196	480,400	*e* 14,942·0	
United Kingdom	175,287	5,452·0	103,332	175,287	*e* 5,452·0	
ASIA:						
Dutch East Indies	85,000	2,643·8	50,107	119,825	3,726·9	
Japan	1,763,135	54,839·2	1,039,367	1,763,135	*e* 54,839·2	
Australasia	10,848,420	337,420·9	6,395,144	9,724,538	302,464·6	
Other countries (d)	48,226	*e* 1,500·0	28,429	48,226	*e* 1,500·0	
Totals	174,851,391	5,438,443·2	$102,769,792	168,936,704	5,097,116·2	$

(a) Statistics compiled from exports and coinage. (b) Statistics furnished by H. R. Wagner. (produced from domestic ores only. (d) The output is mostly from China and Persia. (e) Estimated. timate furnished by Mr. George A. Roberts, Director of the United States Mint. (g) From the *Statis l'Industrie Minerale.*

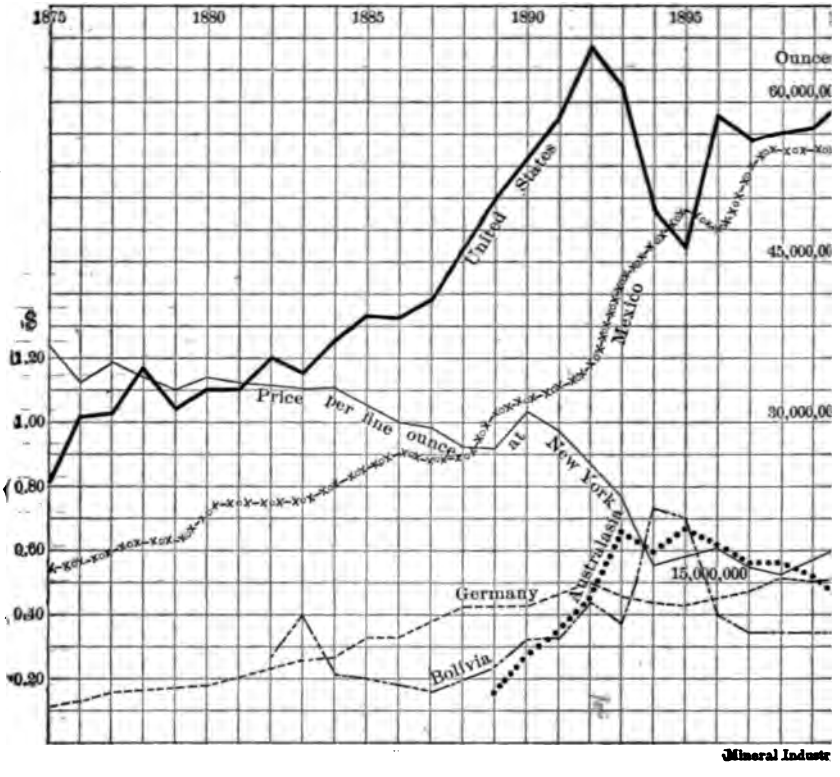
NOTE.—Unless specified to the contrary, the statistics have been taken from official sources or h collected directly from the producers by THE MINERAL INDUSTRY. The average commercial value of s 1901 was 58·95c. per ounce, equivalent to $18·953 per kilogram. The value for 1902 was 58·16c. per ounc *alent to $16·77 per kilogram.*

[illegible] the production of gold in the world in- [illegible] ($ [illegible] kg.), a gain [illegible] In the fifteen years following 1873 there was little change [illegible] between the high mark of $121,513,916 [illegible] ($ [illegible] kg.) for [illegible], the production was $119,000,000 ([illegible] kg.), the



Prices of Silver.

The average prices of silver in New York and London, as computed *Engineering and Mining Journal,* are shown in the subjoined table. T

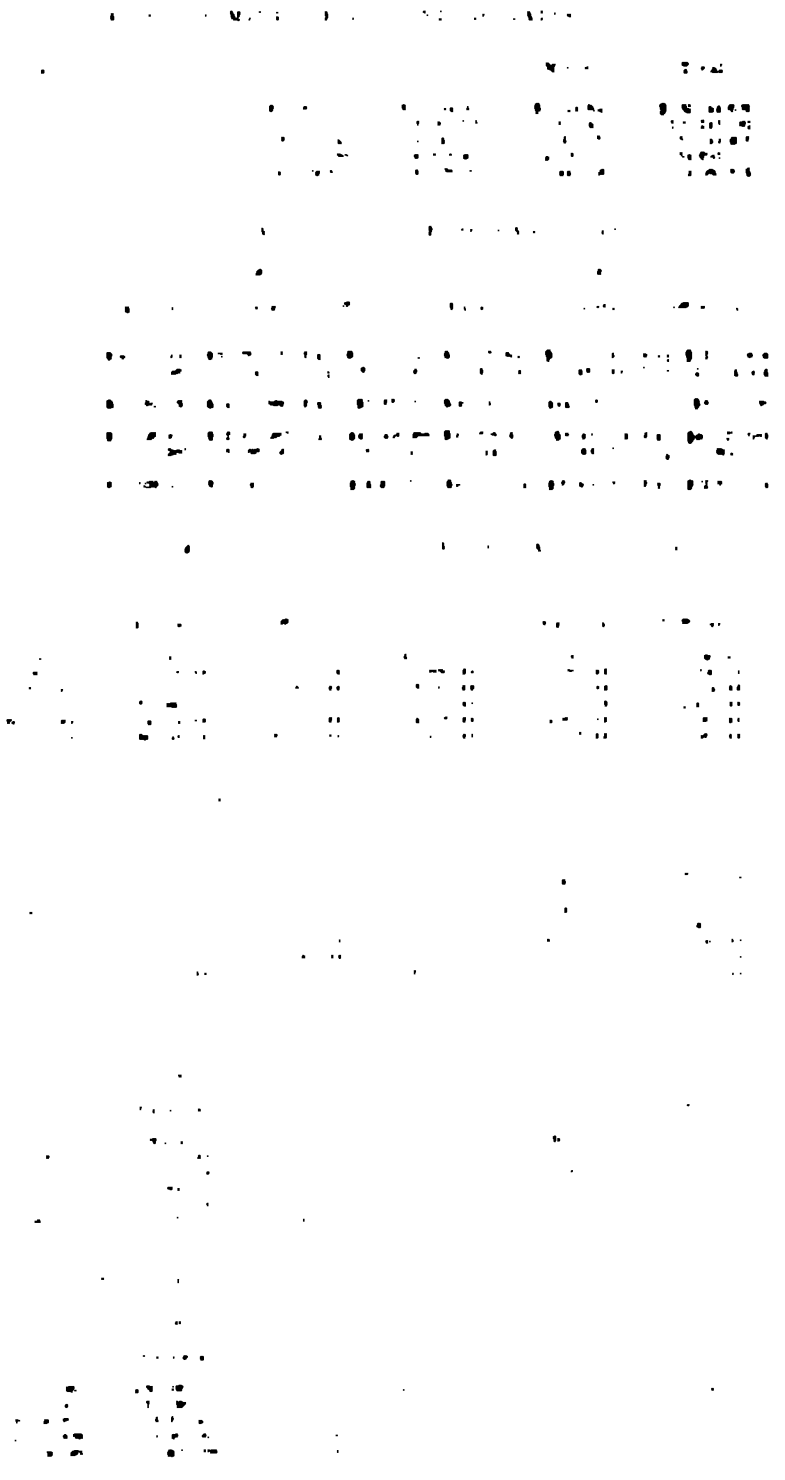


THE PRODUCTION OF SILVER IN THE PRINCIPAL COUNTRIES OF THE

average in 1902 was due to the smaller demand for silver for coinage in the Far East.

Month.	1900.		1901.		1902.		Month.	1900.		1901.	
	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.		London. Pence.	New York. Cents.	London. Pence.	New York. Cents.
January.....	27·30	59·30	28·07	62·82	25·62	55·56	August	28·13	61·14	26·94	58·37
February.....	27·49	59·76	28·13	61·06	25·41	55·09	September	28·85	62·63	26·95	58·26
March	27·59	59·81	27·04	60·63	25·00	54·23	October	29·58	63·88	26·62	57·59
April	27·41	59·59	27·30	59·29	24·34	52·72	November.....	27·66	64·04	26·12	56 64
May	27·56	59·96	27·43	59·64	23·71	51·31	December	29·68	64·14	25·46	55·10
June.....	27·81	60·42	29·42	59·57	24·17	52·36					
July.....	28·23	61·25	26·96	58·46	24·38	52·88	Year.....	28·17	61·33	27·11	58·95

NOTE.—The New York prices are per fine ounce; the London quotations are per standard ou
1 : 0·925 fine.



GOLD AND SILVER MINING IN THE UNITED STATES DURING 1902.

Alaska.—The gradual exhaustion of the rich placers in the Klondike and Ca Nome fields has been followed by increased activity in prospecting for new ter tory, and by the development of low-grade deposits which under former conditio could not be worked at a profit. Many new discoveries have been made in t interior of Alaska, particularly in the region lying between the Yukon and Tana rivers. Glenn Creek, a tributary of Baker Creek, which joins the Tanana abo 80 miles from the Yukon, and Chena River, some 200 miles further up t Tanana, are the sites of the most recent discoveries. Operations are still co ducted on Fortymile River, and the Copper River district is being actively d veloped.

Nome District.—The Nome district, according to reliable estimates, pr duced gold to the value of $5,050,000 in 1902, an increase over the precedi year. Work during 1902 was retarded owing to the small supply of wate it having been the dryest season for several years. A pumping plant was com pleted in the middle of the year by the Wild Goose Mining, Transportation Trading Co., and water was pumped from Snake River, near the town of Nom over Anvil Mountain to Nikola Gulch, 15 miles distant, where it was used o several claims. The daily delivery was 4,500,000 gal. The expense of operati the pumping station was large, coal costing $15 per short ton. This compan working 120 days, produced $1,076,000 gold from its claims in the Nome di trict and on Ophir Creek in the Council City district. The Ophir Creek clain produced $1,250,000 during 1902. The Miocene Ditch Co. has constructed tw ditches to carry water from the Snake River to Dexter Creek, and is also buil ing a ditch to supply Anvil Creek with water from Snow Gulch. The com pany was operating an hydraulic lift at Snow Gulch, and will erect four mo in 1903. Its plant has already cost about $300,000. Several other compani are being supplied with water by the Miocene Ditch Co. The cost of minin with the sluice-box has been from $1 to $2 per cu. yd. The Hot Air Minin Co. has been one of the largest producers, extracting gold to the value of $250,0 during six weeks of operation. Of the other regions during 1902, that arou Boulder Creek, in the Kugruk district, produced approximately $7,000 a Candle Creek in the Fair Haven district, produced about $150,000. The Ir Creek district produced $100,000, and the Solomon River district about $200,0

Juneau and Other Districts.—The Alaska Treadwell Gold Mining Co. repo for the year ending May 15, 1902, that it mined and treated 682,893 tons ore yielding $665,591 in free gold and $639,129 in sulphurets, a total $1,304,720 or $1·9106 per ton as compared with $1,153,368 or $2·07 per ton the preceding year. The profits on merchandise, etc., were $34,799, which ma a total earning of $1,339,519 ($1·9615 per ton). There were 12,408 tons sulphurets saved from the mill tailings by concentration, of which 368 tons r mained on hand at the close of the year. The working expenses were $823,0 ($1·2053 per ton), and the construction expenses $52,942 (7·75c. per ton), maki a total expenditure of $876,029, which left a net profit of $463,490 (67·87c. p *ton*) as compared with $352,559 (77·01c. per ton) in 1901. Dividends

ft. wide averaging $6 per ton. The Eagle-Shawmut mine added 60 stam its 40-stamp mill and began operations with the enlarged plant in August, It is treating 500 tons of ore daily. The North Star Mines Co., durin first eight months of 1902, treated 3,678 tons of ore yielding about $146,0 a cost of $40,000. The North Star Mines Co., Grass Valley, Nevada Co reports that it mined 17,399 tons of ore, realizing $411,148. Total receipt the year were $431,149. The operating costs were $154,228, and total exp were $340,630, leaving a balance of $90,519. The balance on hand a close of the year was $99,001 in cash and $14,711 in supplies at the mine, m a total of $113,712. The Bay Counties Power Co. transmits power fro Yuba River, a distance of 30 miles, and the Butte Creek Power Co. tran power from Butte Creek, a distance of 20 miles, with which to operate the dr The Valley Power Co. is building on French Creek, and at Nimshew, County, another supply is being developed. Power is sold at approximate per H.P. per month.

Colorado.—Mining progress was hampered by the decline in the price of and the exhaustion of several of the large gold mines without a commens development of new districts. The Cripple Creek mines gave a largely incr tonnage, but the total yield of gold was only slightly in excess of that for which shows that a much lower grade of ore was handled than in the pre year. This was made possible by a reduction in treatment charges; a numb companies contracted at the rate of $5·75 per ton, including freight charge ore up to 0·5 oz. With the depletion of the rich ore bodies the future o district depends upon the possibility of new discoveries, and the lowering c working costs. From the numerous developments that have been made in th lying territory, it would appear that no extension of the ore-bearing distri yond the present limits can be expected. There remains, however, a large fie exploration within the district proper, and some of this ground is known t tain good ore. Rich discoveries were reported during the year in the lower ings of the Last Dollar and Blue Bird mines, which are now below the 1,2 level. Plans have been formulated for a drainage adit to be driven in a n easterly direction from the junction of Arequa Gulch and Cripple Creek total distance of about 6,000 ft. It will be 235 ft. below the present water and will drain an area extending from Gold King on the north to El Pas Elkton on the south. Heavy shipments of ore were made from Stratton's pendence mine, particularly from the low-grade ore reserves in the upper The Portland Gold Mining Co., reported a production during 1902 of $2,33 from 89,664 tons of ore, out of which the net earnings amounted to $471,92 reduction of about $1·20 per ton was made on the ore treated by the company' mill at Colorado City. The most important development in the Leadville di was the discovery of an extension of the old bonanza ore-shoots in Fryer Hill. sinking of the El Paso shaft has made possible the unwatering of a large on this hill and opened much valuable ground for exploitation. At the pr time the bulk of the ore tonnage of Leadville is in the form of fluxing iron so that the output is largely dependent upon the rates allowed by the sme *The Tomboy Gold* Mines, Ltd., during the fiscal year ending June 30,

[illegible] tons of ore for a yield of $[illegible], the net profits were $334,317. [illegible] Deer district, the Camp Bird gold mines, which were purchased by [illegible] for $1,[illegible], have given most satisfactory returns. The [illegible] have been largely increased under the new management, and it is [illegible] a new shaft which will be equipped for reaching a depth of 1,500 [illegible] to the decline in ore shipments from the Colorado and Utah mines, [illegible] smelter at Pueblo was closed down.

According to W. H. Huber, the vein of the Parks mine varies in [illegible] from 2 to 11 ft., and assays from $10 to $200 per ton, the average from [illegible] of the ore being $15.60 per ton. The National Mining Co., of Chi[illegible] has a 20-stamp mill at its mine. The shaft has been sunk 150 ft., at which [illegible] is 6 ft. thick and assays $21.60 per ton. The Landers mine, newly [illegible] has two veins varying from 3 to 10 in. and assaying from $30 to $40 [illegible]. The Columbus mine operated by the Columbus Mining Co. is still the [illegible] of the State, the ore from the vein at the 100-ft. level assaying [illegible] per ton. The geology of the Baltimore gold district is described by [illegible] in the *Engineering and Mining Journal* Vol. LXXV., 1903, p. 219.

According to the report of State Mine Inspector, three counties pro[illegible] $300,000 in gold, Owyhee County, $[illegible], Boise County, $[illegible], [illegible] County, $250,[illegible]. The Thunder Mountain district where gold was [illegible] in 1901, did not produce as much gold as was expected. Idaho County, [illegible] reported producing in all but $[illegible]. The Ibex mine owned [illegible] Mountain Gold & Silver Mining & Milling Co., has a 10-stamp [illegible] crushing and that of the Stamps. The gold mines near Wardner are [illegible] by a New Jersey company, which [illegible] water power to operate [illegible]. March [illegible] [illegible] [illegible]

Co., started with 60 stamps driven by electric power from the Canyon Ferry on the Missouri River. The mill and cyanide plant of the Columbia Gold Mining Co. at York was destroyed by fire during the summer. In the Marysville district the Bald Butte mine yielded a steady output of high-grade gold ore during the year. The Drumlummon mine is practically worked out, and on the exhaustion of the old stope-fillings now treated will probably be permanently abandoned. A 500-ton cyanide mill was operated at Empire on old tailings from the Empire mine. In the Phillipsburg district, the Sunrise Gold property is again operating mine and mill; and the Granite Bi-Metallic Co. has decided to double the capacity of the new 600-ton concentrator which was completed late in 1901. A new 50-drill Rix compressor has been installed, and electric haulage introduced in the mine, the power for this purpose and for the mill being furnished by the newly completed electric power plant at Flint Creek Falls. The Bear Gulch mines, near the Yellowstone Park boundary, were tied up by litigation, which is said to be now settled, with a prospect of a re-opening and working of the property on a largely increased scale. The Mayflower mine is to be abandoned. In the Rochester district the Watseca mine is opened up to the 500-ft. level, and a 125-ton concentrator will be added. The Cable mine, near Anaconda, is being re-opened by a Butte syndicate. The Jeannette Mining Co. stopped working on the 100-stamp mill last spring at the Boss Tweed-Clipper group of mines, near Pony, and is awaiting the results of development work. Six dredges have operated during the season, three at Bannock, two near Virginia City and one on French Gulch, near Anaconda. Two of the Bannock dredges will be removed, having entirely exhausted the pay ground. The French Bar dredge has handled gravel profitably at a cost less than 5c. per cu. yd., inclusive of interest on investment, and all fixed charges. The two Bannock dredges were the pioneers in this work in the country, and have extracted over $600,000 from an abandoned placer field. Near Virginia City the boats operating on the old Alder Gulch placers have cost nearly $500,000, but have operated so successfully that other boats, it is reported, will be built. The Montana Mining Co., Ltd., for the half year ending June 30, 1902, reported a net profit of £1,780. This company owns the Drumlummon mine at Marysville, which during the half year treated 13,200 tons of ore for a yield of $61,631. The tailings plant between April 12 and June 30, 1902, treated 31,649 tons of tailings from which $66,310 were realized. The total income was $127,941, and expenses $115,501, leaving a profit of $12,440. The ore and tailings contained 5,622 oz. gold and 31,462 oz. silver.

Nevada.—Development work has been done in the Tonopah district, and new companies have been formed. The Dexter Tuscarora Gold Mining Co. for the 11 months ending Nov. 15, 1902, reports that it treated 30,093 tons of ore at a cost of less than 72c. per ton and extracted $2·88 gold per ton. From 22,930 tons of tailings treated by cyaniding at a cost of $1·10 per ton, it obtained $1·89 gold per ton. Its total receipts were $130,713, and expenses $125,021, of which sum $18,000 were expended in new development work. The Bamberger De Lamar Gold Mines Co., capitalized at $5,000,000, has bought the De Lamar's Nevada Gold Mining Co., Magnolia Gold Mining & Milling Co., Boston De Lamar Gold Mining & Milling Co., Mono Gold Mining & Milling Co., April Fool Gold Mining

placer ground gives returns of from 10 to 12c. per cu. yd., the cost of working being about 1·5 per cu. yd., the water being supplied by the Rouge River. The Golden Drift Mining Co. is building a power dam across the river, and will install ten 600-H.P. turbines, and operate three or four giants. The Galice mines operated by the Old Channel Mining Co. has three 6-in. giants, which obtain their supply of water by means of 18 miles of ditches and flumes. The Eureka mine in the Soldier Creek district owned by the Oregon & California Gold Fields Co. is developing a vein from 8 to 10 ft. wide, which assays from $20 to $35 gold per ton. The Greenback mine on Grave Creek has 35 stamps, and a 60-ton cyanide plant in operation.

South Dakota.—The satisfactory condition of the gold mining industry in the Black Hills during 1902 is evidenced by the increase in output, which was brought about by the enlarged operations of old producers, and by the contributions from mines recently developed. The steady advance recorded in the last few years may be attributed to the introduction of the cyanide process, for with its aid enormous bodies of mineralized material formerly regarded as too low grade for profitable working have been made available for treatment. Full details of the progress in the cyanide process in this State will be found on page 310 of this volume. The Homestake Mining Co. during the year ending June 1, 1902, treated 1,218,089 tons of ore, which yielded bullion valued at $4,314,059. Deducting mint charges the net bullion return was $4,303,977, while the income from miscellaneous sources amounted to $72,453, making the total working receipts, $4,376,427 or $3·60 per ton. The working expenses were $4,017,131, so that the net profits of operation were $359,296, or $0·29 per ton of ore milled. A dividend of $1,260,000 was paid. During the year the stamp mill was increased by 100 stamps, making a total capacity of 900 stamps, and a 900-ton cyanide plant was erected, which increased the cyaniding facilities to 1,900 tons. The Horseshoe Mining Co. was reorganized during the year. The company purchased the 300-ton smelter of the National Smelting Co., at Rapid City, and began construction on a new 1,000-ton cyanide plant. When the improvements and additions are completed the plant will be able to treat 1,600 tons of ore per day. The smelter of the Golden Reward Consolidated Mining & Milling Co., at Deadwood, was in continuous operation, treating ore principally from the company's mines.

Texas.—Although this State produces very little gold, its output of silver is quite large, almost the entire quantity coming from the mine of the Presidio Mining Co., at Shafter in Presidio County. The ore is silver chloride carrying traces of gold, with isolated pockets of lead ore. Three or four carloads of this high-grade lead ore are shipped yearly to the El Paso smelter. The gold ore is treated at the 15-stamp mill of the Cibolo Creek Mining & Milling Co., one mile from the mine. The pulp is ground for three hours with salt, mercury, and copper sulphate in amalgamation pans, of which there are twelve. The amalgam is collected in six settlers, and retorted. The tailings are again milled. The process requires six hours for completion, the mill treating 62 tons of ore per diem, and the average extraction being 85%.

Utah.—There was no material change in the mining situation during 1902.

& Refining Co., and has shut down its plant pending the completion of the smelter of the United States Mining Co., which now owns this mine. The Mammoth mine is engaged in litigation with the Grand Central mine, and until a settlement has been made the work on both will be retarded. The ores of the Tintic district are subject to high smelting charges, and ores up to $15 value do not pay to treat. The largest mines in the Mercur district are operated by the Consolidated Mercur Gold Mines Co., which during the year ending June 30, 1902, produced gold to the value of $1,457,064. The company's working expenses were $1,116,692, and the net profits $342,085. Six dividends amounting in all to $235,000 were distributed during the year.

Washington.—It is estimated that the total production of the Republic district in Ferry County up to Jan. 1, 1902, is about $1,400,000 in gold and silver, the silver being only a small percentage of the whole. The ore averages from $12 to $16 per ton, and the present cost of mining and smelting is $10 per ton. The Republic mill treats 200 tons of ore per day, but like most mines in this State, the smelting ore is shipped to the Granby smelter, at Grand Forks, or to the Northport smelter, near the Canadian boundary. The California mine in Ferry County from July 15 to Dec. 30, 1902, produced 3,411 oz. gold and 4,346 oz. silver. The Hollyhock group, also in this county, mined ore which assayed on the average 0·3 oz. gold, 5·3 oz. silver, 10% Cu, and 9% Pb per ton. The San Poil mine, Ferry County, shipped ore to the Granby smelter, and showed a net profit of $8·80 per ton on ore, which assayed $17·80 per ton. The reserve ore of this mine on Oct. 4, 1902, was estimated at 22,000 tons. The Park City claim of the Cliff group, is developing a vein of galena 700 ft. long and 22 in. wide, which assays 69% Pb, 33 oz. silver, and 0·2 oz. gold. In the Pride and Mystery mines in the Monte Cristo district, the ore varies from 0·6 to 0·95 oz. gold and from 7 to 12 oz. silver. In the Independent mine, at Silverton, Snohomish County, the low grade ore assays $7 per ton, while the high-grade ore varies from $40 to $50 per ton. The ore consists of pyrite and löllengite with a little galena and zinc blende. A mill of from 100 to 200 tons capacity is to be erected.

Wyoming.—(By Wilbur C. Knight.)—There was no marked advancement made in gold and silver mining during 1902. As usual, the Sweetwater district furnished nearly all of the gold and silver ore produced during the year. At South Pass, Atlantic, and Lewiston, considerable property changed hands in the fall and a number of new companies entered these fields. The indications are that these camps will be very active during 1903. In November the Home Placer mine on Douglas Creek near Laramie passed into the control of a company which expects to install a dredge to work the property. In the Wood River district, near Kirwin, Big Horn County, several companies have done sufficient work to patent many claims. The ores of this camp are lead and silver chiefly, and assays showing upward of 100 oz. silver per ton are not uncommon. At present this camp is too far from transportation to handle the ores successfully. In Crook County there has been much activity in the vicinity of Welcome, and not far from the Interocean mine. Several companies have bonded property, and expect to inaugurate extensive plans for work in 1903.

Knob Hill, Old Ironsides, and Snowshoe, near Phœnix, and the Mother-Lode and Sunset, about three miles west of Greenwood. These mines in 1902 shipped to three smelters in the vicinity over 500,000 tons, an increase of 125,000 tons over 1901, due to increased smelting facilities. At the three plants are seven furnaces having a daily aggregate capacity of about 2,500 tons. Three other

OUTPUT OF TRAIL CREEK MINES FROM 1898 TO 1902.

Year.	Tons of Ore.	Gold. Oz.	Value.	Silver. Oz.	Value.	Copper. Lb.	Value.	Total Value.
1898.....	111,282	87,343	$1,746,861	170,804	$94,539	5,232,011	$339,411	$2,470,811
1899.....	172,665	102,976	2,127,482	185,818	105,173	5,699,889	996,431	3,229,086
1900.....	257,636	111,625	2,306,172	167,378	97,648	2,071,805	385,495	2,789,309
1901.....	283,360	132,333	2,735,323	970,460	548,458	8,333,446	1,342,518	4,621,299
1902.....	329,534	162,146	3,351,558	373,101	184,871	11,667,807	1,356,966	4,893,395

furnaces are in course of construction. Free-milling gold ores are found at only a few widely separated points. The Ymir mine, 20 miles south of Nelson, is the largest mine of the class, and last year produced over $300,000 in gold, together with silver and lead valued at about $15,000. The Cariboo-McKinney mine at Camp McKinney in the south-central portion of Yale district, is the next largest free gold producer, and has been a steady profit payer since 1894. The Granite-Poorman and Athabasca-Venus, near Nelson, run regularly, and the Stemwinder, near Fairview in the western part of the Yale district, is about to be added to the list of producers. The gold derived from this class of ores amounted in 1902 to approximately $650,000. Some of the lead ores of Slocan and Lardeau carry appreciable values in gold, and there are also dry smelting gold ores at various localities in southern British Columbia. The latter class of ores has not as yet been largely produced.

Silver-lead mining under former conditions has been a profitable industry owing to the high ratio of silver to lead in the ores which last year was slightly over two ounces to each unit of lead. The low prices that prevailed during 1902, together with the fact that the shortage of lead has lessened the demand for dry ores, and also that many former clean ore mines have had to resort to concentration, have tended, however, to extinguish profits except in a few instances. Silver mining at present is in an unsatisfactory condition. The gold-copper ores of Rossland and Boundary carry respectively, about 1 oz. and 0·5 oz. silver per ton; and although this is a small average the aggregate output from these districts was nearly 593,000 oz. The gold-milling ores also carry small amounts of silver, *e. g.*, the Ymir mine bullion contains about 40%, and the concentrates about 12 oz. silver per ton. Under improved conditions East Kootenay is capable of producing much silver, but because of the low ratio of silver to lead in the ores low prices have affected that district possibly more seriously than they have West Kootenay. The Slocan portion of West Kootenay continued to furnish the greater part (nearly 65%) of the total output of silver.

Dawson.—According to official authorities, the production of gold in the Yukon district during 1902 amounted to about $18,000,000, a decrease of $4,000,000 from the output of the previous year. In arriving at these statistics there are *two uncertain* factors, one the quantity of gold which is carried out of the country

Oak Mining Co., at Goldenville, operated mainly at the western end of its property. The Baltimore and Nova Scotia Mining Co. was very active. The main shaft of the mine is now 700 ft. deep, intersecting at the 500-ft. level the lenticular fissue vein in the form of a chimney. The 40-stamp mill is well arranged. Although inoperative at present the St. Anthony mine is being kept unwatered.

Ontario.—In Eastern Ontario the principal properties are the Belmont mine operated by the Cordova Exploration Co. and the Deloro mines of the Canadian Goldfields, Ltd. The Belmont veins consist of free milling quartz which is treated in the 30-stamp mill and amalgamation plant, the pulp being subsequently cyanided. At Deloro, the ore is mixed quartz and mispickel, from which the gold is extracted by leaching with bromo-cyanide solutions, and the arsenic by a process of sublimation (see "Arsenic" elsewhere in this volume). In the Lake of the Woods district the Black Eagle mine, formerly known as the Regina mine, has been actively operated during the past two years, and the mill thoroughly overhauled. The present equipment includes a 30-stamp mill. A 250-ton cyanide plant is being constructed for which about 1,500 tons of concentrates, valued at from $35 to $50 per ton, have been accumulated. The Sultana mine, operated by the Sultana Mine of Canada, Ltd., has not proved very successful. During the fiscal year ending Sept. 30, 1901, 7,000 tons of ore were milled, which yielded an average of only $5·15 per ton. Although the mining costs of the Mikado Gold Mining Co. averaged but $3·50 per ton of ore during 1901, a debit balance of £5,052 is given in the report of the company. Operations at the Sakoose mine, owned by the Ontario Gold Mining & Milling Co., were suspended in March, 1902, owing to the exhaustion of the ore in the levels under development. In all 7,735 tons of ore have been removed from the stopes. Prospecting was actively carried on in the Sturgeon Lake region, and several companies have developed mines or erected mills, notably, the United States Gold Mining Co., the Sturgeon Lake Mining Co., the Jack Lake Gold Mining Co., Ltd., and the Anglo-Canadian Gold Estates, Ltd. A deposit of gold-bearing gravel similar to that of the Vermilion River was discovered at Savant Lake, 150 miles north of Ignace, and an examination over an area six miles long by one mile wide, showed an average value of from 8 to 10c. per cu. yd. The gold is in small rounded particles. Robert H. Ahn, of Toronto, reports satisfactory experimental treatment of Vermilion River gravels by a combined amalgamation and cyanide process.

Mexico.—(By James W. Malcolmson.)—(The output of gold and silver is derived largely by smelting gold and silver ores with those of copper and lead, and it is practically impossible to classify the subject under the heads of the respective metals without causing duplication. Therefore reference should also be made to the "Progress of Mining in Foreign Countries," under the sections devoted to "Copper" and "Lead," elsewhere in this volume.)

Owing chiefly to the cheap mining and the absence of labor troubles, there has been a large influx of foreign capital seeking investment in silver, gold, copper and lead mines. From a wage standpoint, a ton of ore can be mined in Mexico for 40% of the cost of mining similar ore in the United States, assuming that the miner in the latter country does twice as much manual labor

ably in the southern part of the State, and a number of good lead-silver prospects are being developed. At Viesca a smelter has been erected to treat the low-grade siliceous copper carbonates, which carry some silver. The output of the Sierra Mojada was greatly reduced owing to the burning of the El Paso smelting works. The Fortuna mine has been actively worked, due to the discovery of a rich deposit of silver-lead carbonates. The fire in the San Salvador mine continued throughout the year—the mine contains 30,000,000 ft. of lumber and immense quantities of native sulphur. In the Fronteriza mine, a valuable extension of the main ore zone has been discovered, but operations here and in the adjoining Encantada mine of M. Guggenheim Sons were hindered by the fire in the San Salvador mine. The Norias de Banjan, Cerralvo and Cuatro Cienegas silver-lead camps were operated in a small way throughout the year.

Durango.—The silver-lead-copper mines and smelter of the Velardena Mining & Smelting Co., of Omaha, were sold in November to the American Smelting & Refining Co., an action which will have a radical effect on the smelter situation. The Compañia Minera de Peñoles, at Mapimi, mined 171,000 metric tons of ore in 1902, and produced 92,000 kg. silver and 24.000 metric tons lead. The ore occurs in a series of irregular pipes which have been explored by diamond drills to a depth of 2,300 ft. Thirty electric hoists from 1 to 50 H.P. are used successfully in opening up the ore reserves. A complete reverberatory roasting plant has been installed. Due to the extension of the International Railroad to Chinacates, the Promotono silver-gold siliceous mine has installed a concentrator and a 100-ton smelter. The Lustre Mining Co., of Pittsburg, operating the Magistral mine near Inde, is experimenting with the treatment of the ore which assays 0·5% copper and 0·5 oz. gold per ton. Guanacevi, which is probably the most important siliceous district in the country, continues to be handicapped with high freight rates and heavy milling losses—the work on the extension of the International and Central railroads having been suspended. Development work at the Avino Mines of Mexico, Ltd., has shown the presence of copper oxide with native copper in the lower leads. The concentration works has been superseded by a thiosulphate leaching plant which extracts 85% of the silver and 30% of the gold. The Vacas mines shipped high grade silver-lead concentrates low in silica. The ancient Rosario mine is being reopened, and the old workings contain large quantities of silver-gold ore amenable to profitable treatment by leaching processes. The San Andres de la Sierra silver-lead mine ships $100,000 of base bullion monthly. The Bacis Gold and Silver Mines, Ltd., operates 40 stamps, and concentrates and amalgamates its ore. The Cushing & Walkup Co., at Trinidad smelts siliceous gold-silver-copper ore, and ships to the Aguascalientes smelter, which yields copper matte assaying 20% copper, 350 oz. silver and 8 oz. gold per ton. The Candelaria Consolidated Mining Co., at San Dimas, increased its yearly output, which is obtained by stamps and pan amalgamation. At La Puerta a large body of gold-silver ore has been uncovered and a mill is under construction. The value of the ore produced annually in the State of Durango is second only to that of Chihuahua.

Guanajuato.—The ancient siliceous silver-gold mining district of Guanajuato has been actively operated. These mines are believed to have produced one-sixth

marketed. On the Santiago River the Castellanos gold-silver mine has been purchased by the Mexican Gold & Silver Recovery Co.

Mexico.—The El Oro gold mines have been operated successfully, but the scarcity of fuel is becoming a serious feature. The owners of the Dos Estrellas mine have cut a rich and productive ore body. El Oro Mining and Railway Co. has acquired a large number of claims adjoining its properties. This camp is the richest gold mining district in the Republic. The ore occurring as gold quartz in shale is crushed, carried over plates, and the residues cyanided yielding 80% of the total values. The adjoining camp of Tlalpujahua is a silver camp, and the change to gold mining in this district resembles the similar change in Colorado after 1893.

Michoacan.—The operations of the Inguaran Copper Co. have not increased during the year. The French owners have not yet decided to build the contemplated electric power transmission plant. In Angangueo 2,000 tons of silver-bearing iron pyrites have been mined monthly. The ore carried over 20 oz. silver per ton, 8% zinc blende, with some galena and 30% sulphur. This ore was formerly roasted in open heaps and shipped as an iron flux to Aguascalientes, but the crude ore is now shipped to the same point, and used in the copper plant.

Oaxaca.—The Oaxaca and Ejutla Railway has been extended into the district of Taviche, and the operations in the Ocotlan mining camp have been very active. The principal mine in the district, the Escuadra, containing siliceous silver-gold ore, has been purchased by Omaha capitalists. About 1,500 tons of ore, assaying 90 oz. silver, and from 0·2 to 0·5 oz. gold per ton is being shipped monthly, and a local treatment plant is under construction by the Taviche Milling Co. The gold-silver ore bodies of Ixtlan are being worked very actively, and large profits are being made by the owners of the Natividad mine.

Puebla.—The pyritic deposit of basic, silver-gold, zinky copper ore at Tezuitlan has been actively worked throughout the year. The ore is now being smelted at the rate of 5,000 tons per month, and the copper matte converted into blister copper. Power is obtained from a 1,000-ft. water fall and transmitted five miles to the mines and smelter.

San Luis Potosi.—A new bonanza has been found in the sulphide zone of the La Paz silver mine in Matehuala, which assures the future of the mine for a long time. The monthly production is 4,000 tons of ore assaying from 45 to 50 oz. per ton. The Guggenheim Exploration Co. has secured in Matahuala, the Trinidad mine and the stock of the Azul mine, both adjoining the Dolores property, which is a producer of copper ore carrying silver and gold. In Charcas the Tiro General silver-zinc mine is being developed, and a considerable tonnage of ore was shipped.

Sonora.—The Yaqui Indian uprising has disturbed conditions in the southern portion of the State, and freighting has almost ceased in the central portion from the lack of pasture. The Picacho mine north of Arispe, belonging to Phelps, Dodge & Co., made regular shipments of high-grade siliceous gold ores, and the Chispa mine, south of Arispe, again commenced to ship high grade gold-silver ore. The development of mining in the Sonora, Oposura and Yaqui valleys is *greatly retarded* by the excessive cost of transportation to the Sonora Railroad.

Abengarez Co. is substituting water power (300 H.P.) with electric transmission, for steam power, enlarging its mill and cyanide plant, and putting in air compressors for drilling. The ore averages 15 dwt. gold per ton. The average value of the ore of the El Porvenir mine, now owned by the Rio Grande Gold Mining Co., is from $40 to $60 per ton. A new 1,000-ft. main tunnel was to be built and power drills were to be installed in May, 1902.

Honduras.—The production of precious metals during 1902 was 23,234 oz. gold and 1,010,204 oz. silver. The report of the New York & Honduras Rosario Mining Co., for the fiscal year ending Nov. 30, 1902, states that dividends amounting to $105,000 (7% on the capital stock of the company) have been paid during the year, making the total dividends to date $1,800,000. The expenditures for the year including dividends amounted to $631,245, while the income from interest and sale of bullion amounted to $490,274. The surplus at the end of the fiscal year was $842,294. The ore in sight is estimated to be about 30,000 tons. The company is now shipping the concentrates to the United States. A Herreshoff roaster and a reverberatory furnace are being erected in order to reduce the quantity of concentrates to be shipped. The Aramecina mines continued in operation. The Ulna Co. is surveying a road in order to develop the Olancho gold mining district. It is believed that the line can be built in two years.

Nicaragua.—In Nueva Segovia and Prinzapulca, placer mining on a small scale is being done. In the vicinity of Rama there are rich mines. The El Mico mine employs a 20-stamp mill, the ore vein being 22 ft. thick.

Salvador.—The Loma Larga mine has a 3-ft. vein, which averages $20 in gold and silver. The main shaft is 394 ft. deep, and the main level is 1,640 ft. long. About 30,000 tons of ore have been taken from this vein, but water now prevents further working. The San Francisco vein is 6·5 ft. wide and assays $10 per ton of ore in gold and silver, the gold being free. The main shaft is 230 ft. deep with 1,640 ft. of drifts. The Mantos del Socorro and De la Senora mines yielding ores which assay $12 gold per ton, are operative, 600 tons of ore were treated by the cyanide process. The capacity of the plant is 40 tons per day, and 150 men, all natives, are employed. The exports of gold in 1901 were $192,735, a large increase over the exports for the previous years.

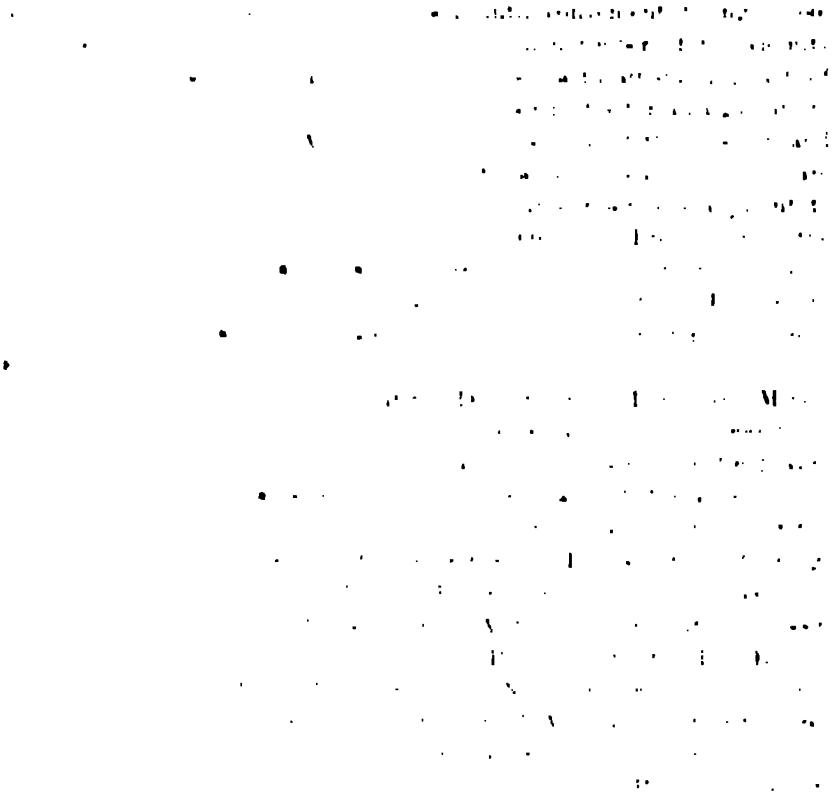
South America.—*Argentina.*—The Famatima Development Corporation, Ltd., capitalized at £400,000, has been formed to take over the Famatima Copper and Gold Syndicate, Ltd. The mines are in the Mexicana spur of the Famatima Range. There are 14 lodes of ore averaging 4 ft. in width and two miles long. An aërial tramway is being built to the town of Chilecito, a distance of 25 miles, which will reduce the cost of carrying ore to the smelter from 35s. to 2s. per ton. Water is abundant, and the cost of labor 2s. 2d. per day. The ore, which contains gold, silver, and copper, on smelting 30-ton sample lots, gave results varying from £7 15s. per ton to £22 10s. per ton. The Rosario Co. is operating a 36-in. water-jacket blast furnace for copper in the Calamuchita district, 60 miles southwest of Cordoba City. The ore smelted consists of chalcopyrite and pyrite in quartz, yielding from 5 to 6% Cu. The 65% matte product containing 30 oz. silver per ton is exported. In the Rioja province, an Otto overhead wire rope tram-

H. Kilburn Scott in a paper read before the American Institute of Mining Engineers, May, 1902. Veins of gold in quartz, assaying 470 g. per ton (equivalent to $235 in value) are reported to have been found in Tassaras, 2 km. distant from the Ouro Preto mines. Dr. Timothes Da Costa reports the results of 10,500 pan washings of gravels from the Carno River to average 3·13 g. gold per ton.

Chile.—The South Chilean Syndicate, capitalized at £32,000, operated placers near San José, but the Valdivia Co., with a capital of £15,000, which started operations at Panquinlahue, suspended work. A gold mine is being operated at Quinco. During 1902 a company operating the cyanide process on old mill tailings, extracted and shipped gold precipitate to the value of $80,000, and the Anglo-Chilean Exploration Co. at Huasco produced from 10 to 11 kg. gold per month from its stamp mill. The principal silver mines which produce about 7,000 oz. per month, are located in the district of Caracoles, 150 miles inland from Antofagasta. Operations are carried on by the leasing system, the lessees paying the owner of the property a royalty of from 15 to 30% upon the net value after deducting mining expenses. The silver-lead smelting works are at Antofagasta, one being in the suburb Bella Vista, owned by the Antofagasta Smelting Co., and the other at Playa Blanca, owned by the Compañia de Minas de Huanchaca. American and French capitalists are interested in the Huanchaca company. Up to March 1, 1903, the Chilean Government melted and sold in the London market 3,300,000 silver soles, replacing the coinage by imports of gold —a step necessary in order to maintain the gold standard.

Colombia.—The continuation of the civil war has hindered the active development of mining, although in the interior of the country operations have been conducted successfully. The Province of Antioquia produces 90% of the total output of gold, which during the past few years has exceeded annually $2,000,000 in value. Silver ore is exported chiefly to Germany and England, in value amounting annually to about $1,500,000. The Zaucudo mines operated entirely by native management employed nearly 2,000 people in 1902, and produced about $20,000 in bullion per month. The Frontino and Bolivia Gold Mining Co., Ltd., which owns the Salada and Silencio mines, operates three California and several native wooden mills. The Leristales and San Nicolas mines, with a 35-stamp California mill, are in operation again after having been closed during the revolution. The Colombian Mines Co. has a native 24-stamp mill at its Venecia mine, and will erect a California mill. The Bramadora mine is being developed, and a Californian 80-stamp mill will be erected. At the San Andres mine, there are over 26,000 tons of ore reported in sight, valued at $42·63 per ton, and 5,000 tons of tailings, valued at $28 per ton. The ore is iron pyrites carrying a little galena and zinc blende, and the vein averages about 5 ft. wide.

Ecuador.—The South American Exploration Co., of New York, continues to operate successfully the mines in the Zaruma district, Province of El Oro. The principal veins vary from 15 to 16 m. in width. The work is through tunnels, the lowest and principal tunnel being 2,300 ft. in length, reaching a depth of 650 ft. The ore is chiefly blue and white quartz, containing about 10% of iron, copper, zinc and lead sulphides, with occasional free gold. The ore is extracted chiefly by stoping large chambers and filling with surface rock, although small

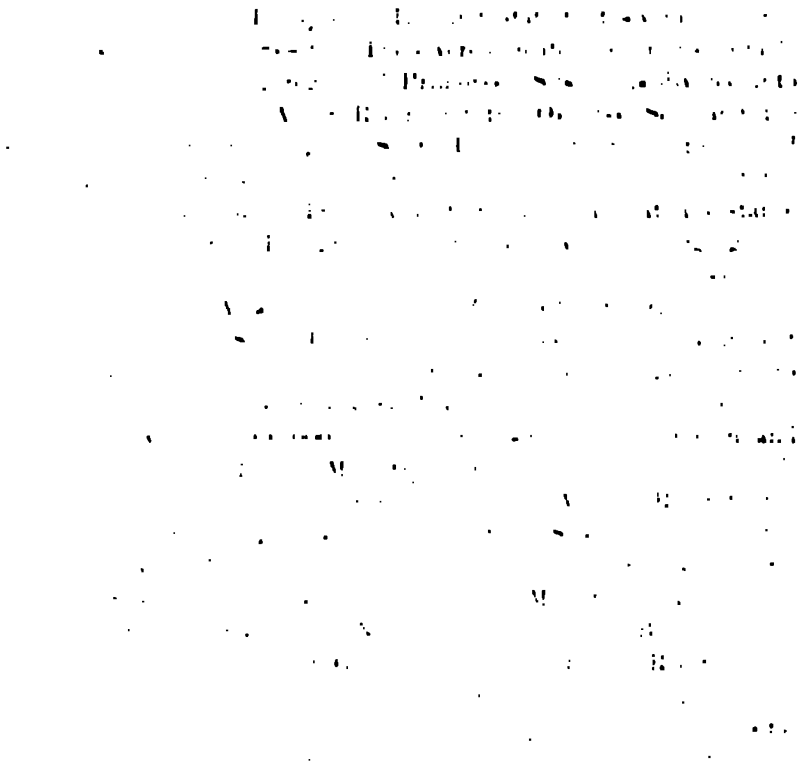


have been 587·6 kg. as compared with 752·8 kg. in 1901. The statistics of export include a portion of the production of French Guiana, which passes through Dutch Guiana on account of the lower Government tax rate in the latter country. The development of the gold mining industry is seriously hampered by the difficulties of transport, an obstacle which will be removed by the construction of the proposed railroad from Paramaribo to the Lawa district.

Peru.—The production of gold during 1900 was 52,480 oz., valued at $1,084,750. The Nimrod Syndicate has acquired the Chuquitambo gold mines near Cerro de Pasco, formerly worked by the Spaniards. A large quantity of ore is available which though not rich is of sufficiently high grade to be treated with profit. A New York syndicate has purchased practically all of the productive properties in the Cerro de Pasco district at a price of $2,650,000, thereby controlling at least 80% of the mines. A railroad from this district to Oroya is under construction, and will probably be completed before the end of the year, which will lower the freight rates to 24 soles ($11·66) per ton from the present rate of from 70 to 80 soles ($34 to $39) now paid for transportation on the backs of llamas. The Caylloma Silver Mining Co., Ltd., operating the San Pedro, Santa Isabel tunnel, Bateas and Eureka mines report for the fiscal year ending June 30, 1902, gross receipts from ore and bullion amounting to £47,541; deducting £2,000 for depreciation the net loss was £3,421. The year's work showed 730 tons of ore shipped, of an average assay of 416 oz. 6 dwt. silver and 1 oz. 1 dwt. gold per ton, the total value being £29,837. Bar silver sold during the year contained 166,051 standard oz. silver and 154 oz. gold of an aggregate value of £17,703. Owing to the decline in the price of silver, it is reported that the company is seriously contemplating a shut-down of the works. The Inca Mining Co., owning mines in the interior of the country, has recently purchased from an American company a $40,000-milling plant, consisting of a 30-stamp mill, 8 Wilfley concentrators, engines, boilers, etc. The machinery was packed in 300-lb. lots as the only means of transportation is on the backs of llamas. During 1902 Barkis & Johnson Co. shipped to London 3,000 tons of copper matte containing from 40 to 50% copper and from 225 to 235 oz. silver per ton. The company is developing rapidly and expects to produce more than double its present output during 1903. The Alpa Mina in the Yauli district, produced 250 tons of ore assaying 40% lead and from 30 to 100 oz. silver per ton.

Uruguay.—The quartz mines of Cunapiru, San Gregorio and Santa Ernestina in the Rivera department, have been operated by a French company, which during 1901 treated 6,183 tons of ore, yielding 72 kg. gold, valued at $47,815, as compared with 7,345 tons, yielding 71 kg. gold, valued at $47,342, in 1900. The cyanide process recently adopted has given better results. The mines are small—mostly surface work—and assays from 12 workings range from 6·75 to 30·79 g. ($4·50 to $20·50) per ton. During 1901, 25 new applications for mining privileges were filed in the departments of Cerro Largo, Minas, Maldonado, Canelones and Florida. A serious obstacle to the development of the mines is the lack of water. A percentage of the total output of gold is paid to the Government.

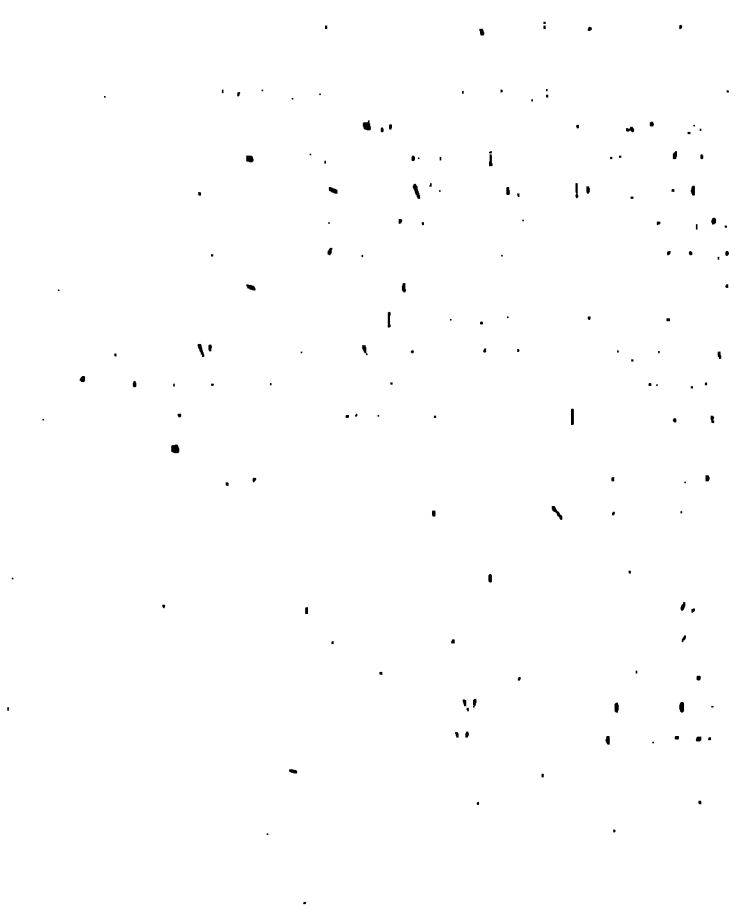
EUROPE.—Russia.—Reports of operations at the so-called "Finnish Klondyke"



of the Egyptian Exploration Co., has been capitalized at £150,000. The district owned by the company occupies 1,200 sq. miles. Two ancient gold mines have been rediscovered—the Fowkir and the Um Esh. The quartz vein in the latter is half a mile long and from a few inches to a foot thick. A part of the ore assayed 11 dwt. 12 gr. gold per ton. In the Fowkir mine samples assay from 1·5 to 5 dwt. gold per ton. Labor is abundant and cheap, but fuel and timber will have to be imported; the mines, however, are easily accessible from the coast. The Nile Valley Co. in its report of March 5, 1903, states that it has received a concession of 6,000 sq. miles from the Egyptian Government. At the Um Garaiart mine, owned by this company, there is a complete hoisting and pumping plant and a small battery is being erected. Three shafts have been sunk, the reef varying from 18 in. to 9 ft. in thickness, and the ore assaying from 20 to 250 oz. gold. Ore valued at £11,000 has been taken out of the mine. The Egypt & Soudan Mining Syndicate, Ltd., for the year ending September 30, 1902, reports that its concessions in Egypt comprise an area of 2,000 sq. miles, and in Soudan about 20,000 sq. miles. On its Egyptian property at Hamesh three shafts have been sunk, the ore assaying from 12 gr. to 1 oz. 4 dwt. per ton, and at Samut three other shafts show the vein to vary from 0·5 to 1·5 ft. in width and to assay from 2 dwt. to 2 oz. 18 dwt. per ton. On its Soudan property investigation and development work have been carried on at Om Nabardi and Nabi, and it has been found that the ore assays from 5 dwt. to 1 oz. 16 dwt. gold per ton.

Gold Coast.—According to the Controller of Customs at Accra, the exports from the Gold Coast Colony during 1901 amounted to 6,163 oz. bullion, equivalent to 5,224 oz. fine gold, valued at £22,187, as compared with 10,557 oz. bullion, valued at £38,007, in 1900. The Asiakwa Hydraulicking & Mining Corporation, Ltd., owns 20 sq. miles of territory; a test on 338 cu. yd. of gravel gave by hydraulic mining 20 oz. 1 dwt. gold assaying 930 fine. A plant is to be built to produce 40 oz. gold per day. The New Gold Coast Agency, Ltd., has acquired the Gold Coast Agency, Ltd., and obtained large concessions in the Tarkwa district belonging to the Nassau Gold Coast Mining Co., Ltd., and the Gold Coast Pioneer Syndicate, Ltd. The new company has formed two subsidiary companies—the Adjak Bippo Deep, Ltd., and the Cinnamon Bippo Co., Ltd.—both capitalized at £100,000. Both of these latter companies are developing their properties. The reef of the first varies in thickness from 10 to 44 in. and assays from 2 to 23 dwt. gold per ton, while the reef of the second varies from 2·5 to 18 in. and assays from 3 to 24 dwt. gold per ton.

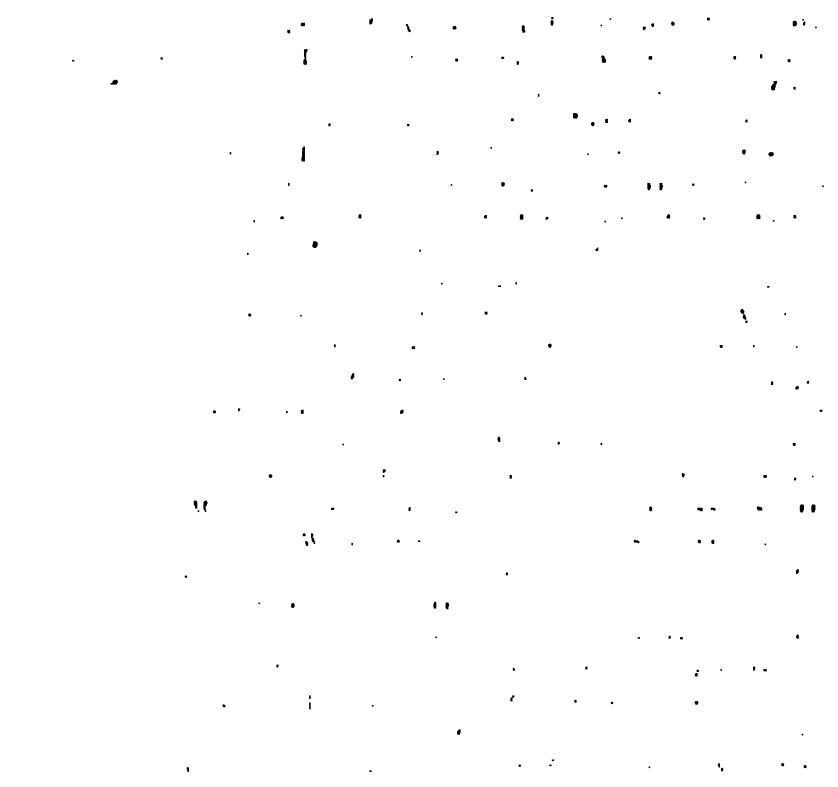
Ivory Coast.—The Consolidated Goldfields of the Ivory Coast, Ltd., increased its capital to £1,000,000 after taking over the property of the New Austral Co., Ltd. The concession owned by the company covers 2,000,000 acres. The New Austral properties are situated in the districts of the Baoulé, Sanwi, Indénié, Attie and Biano rivers. The sample of the ore taken from the Amangara reef assayed from 1 to 18 oz. gold, and from 0·5 to 2 oz. silver. Engineers have been sent out to investigate the property. On the bank of the Menzan River quartz has been found which assays from 2 to 30 dwt. gold per ton. At Assikasso,



it is estimated that there are 53,000 tons of ore in sight averaging 15 dwt. gold per ton. In the West Nicholson mine the ore in sight is estimated at 70,000 tons, assaying from 8 to 12 dwt. per ton, in addition to large tonnage of low grade ore. The 10-stamp mill is to be increased by the addition of 50 new stamps. The Red and White Rose mine has erected a 20-stamp mill and cyanide plant. Its ore assays 12 dwt. gold per ton. The Rhodesia Exploration & Development Co., Ltd., during the fiscal year ending June 30, 1902, was engaged in developing its six mines, excavating 12,635 yd. material at an average cost of £2 18s. 2·6d. per running foot. The Ayrshire Gold Mine & Lomagunda Railway Co., Ltd., for the year ending June 30, 1902, reports that the railroad from Salisbury to the mine has been completed. Its mine is being developed, 62,100 tons of ore averaging 10 dwt. having been blocked out. Its 5-stamp mill, which crushed 7,033 tons of ore yielding 3,895 oz. of bullion between April, 1900 and August 31, 1901, will be increased, and a cyanide plant added. The V. V. (Gwanda) Syndicate, Ltd., is also developing its ten properties and a 10-stamp mill is to be erected. It has sold three of its properties to the Imani Gold Mining Co., Ltd. The Selukwe Gold Mining Co., Ltd., for the year ending March 31, 1902, reported that it crushed 62,301 tons of rock yielding 38,049 oz. bullion, and treated in its cyanide mill, which was completed in October, 1901, 28,160 tons, yielding 6,472 oz. bullion. It realized from the sale of gold £159,862, and its total income was £160,101. The net profit for the year was £43,898, which with £52,275, the balance brought forward from the previous fiscal year, made a total balance of £96,171. A dividend of 10% was paid in August, 1902.

Transvaal.—(We are indebted to W. Fischer Wilkinson[1] for valuable information contained in this review.)—The opening of the year 1902 found the war still in progress, although the British troops were able to maintain tranquil conditions throughout most of the colony. By December, 1901, only 11 companies had taken advantage of the order issued in May granting permission to resume operations on a small scale, and the number of stamps dropping was only 653 out of the 5,970 at work before the war. As the difficulties incident to repairing damages, procuring supplies and getting a sufficient quota of native laborers were overcome, the list of operative mines was gradually increased. In January, 1902, 21 companies with 1,075 stamps were working; in April, 33 companies, 1,760 stamps; in June, 37 companies, 2,130 stamps; in August, 39 companies, 2,395 stamps; in October, 41 companies, 2,570 stamps, and in December, 45 companies, with 2,845 stamps. Hostilities ceased on May 31, 1902, when the peace negotiations were signed by the two parties. The losses sustained by the mining companies on account of the war were heavy, although little wilful damage was committed by the Boers. The largest item—the costs of care-taking, unwatering, repairs, salaries and wages—amounted to £3,400,000; while the gold appropriated by the Boer Government from the mines was £2,475,178. Exclusive of interest on capital the total loss may be placed at about £6,000,000. In some respects the changed conditions under the new rule have been for the benefit of the mining companies. The latter have profited

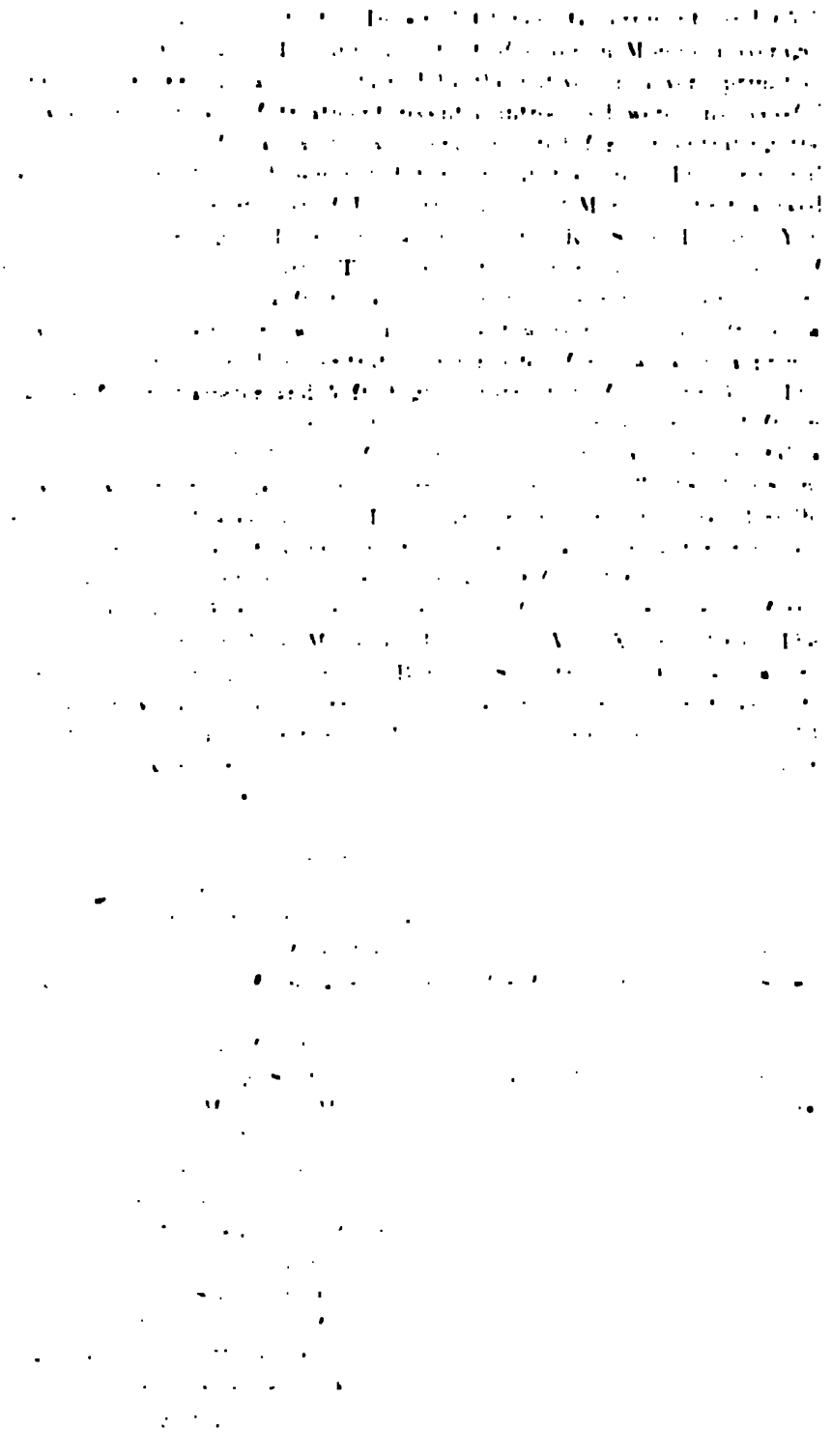
[1] *Engineering and Mining Journal*, Jan. 3, 1903, p. 16.



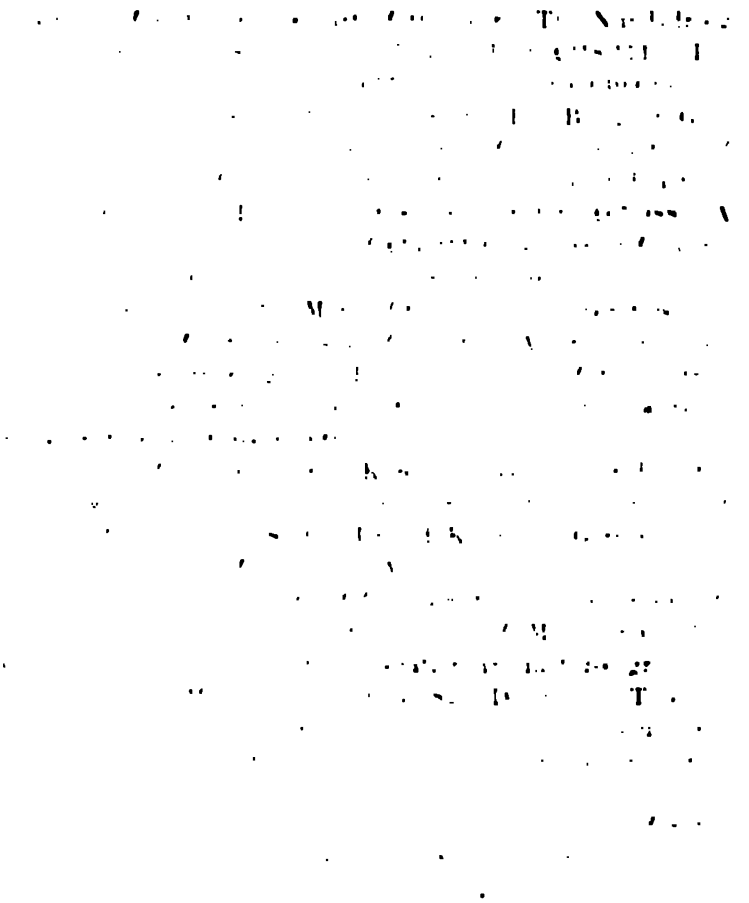
ward from the previous year, £1,512,206, makes £2,175,928, out of which a dividend of £500,000 is to be paid, leaving £1,675,928 to be carried forward. The Robinson Deep Gold Mining Co., owned by this company, re-started in March, 1901, with 50 stamps, and between March 1 and August 30, 1901, the company milled 48,615 tons of ore, yielding 23,934 fine oz. gold, valued at £99,452. The working expenses amounted to £81,355, leaving a profit of £18,097. The Glen Deep, Ltd., for the year ending July 31, 1902, states that operations were resumed in March, 1902, and between March and July 31, 1902, it crushed 27,328 tons of ore with 35 stamps, yielding 9,380 fine oz. gold, valued at £39,336; the expenditures during the same period amounted to £32,682, leaving a profit of £6,653, from which must be subtracted interest charges of £2,481, making the net profit £4,173. The ore reserves were estimated at 383,694 tons. The Simmer and Jack Proprietary Mines, Ltd., for the year ending June 30, 1902, reports a resumption of operations April 23, 1902, with 50 stamps, which were increased to 100 in June. The total tonnage crushed was 28,404, yielding 8,225 fine oz. gold, valued at £34,642, and the working expenses were £35,608. The 40 additional stamps started before the war were completed, increasing the capacity of the plant to 320 stamps, and a drying and a reverberatory furnace were built for drying and smelting the gold slimes. The Jumpers Deep, Ltd., for the year ending September 30, 1902, reports that it resumed operation in February, 1902, and in eight months treated 74,146 tons of ore, yielding 26,115 fine oz. gold valued at £109,152, and expended £95,090, leaving a net profit, after paying interest charges of £966, of £13,096. The ore reserves on September 30, 1902, were estimated at 619,137 tons. The Langlaagte Deep, Ltd., for the year ending July 31, 1902, reports that during seven months it milled 66,531 tons, yielding 25,433 fine oz. gold, valued at £106,448, and expended £81,284 for operating its property, and £25,161 for interest. The ore reserves on July 31, 1902, were estimated at 762,317 tons. The Nourse Deep, Ltd., for the year ending July 31, 1902, reports that during five months it milled 36,008 tons of ore, yielding 10,484 fine oz. gold, valued at £43,637, and expended £40,905 for operating its property, and £316 for interest, leaving a net profit of £2,416. The ore reserves on July 31, 1902, were estimated at 495,126 tons.

West Africa.—In January, 1903, the Prah Gold Mines, Ltd., the Clinton's Gold Concessions, Ltd., the United Gold Mines of West Africa, Ltd., the Atomé Mines, Ltd., and the Bakrobo Mines, Ltd., were consolidated. The consolidated company owns 1,000 sq. miles in West Africa. The nominal capital at the time of consolidation was £900,000, of which £694,000 had been paid in. The name of the present company is the United Gold Mines of West Africa, with a nominal capital of £500,000, of which £464,000 were issued at once, leaving £36,000 to be issued as required.

ASIA.—*China.*—The Syndicat du Yunnan, Ltd., has obtained a concession from the Chinese Government for a period of 60 years to exploit the mines and mineral deposits in 35 districts of the Province of Yunnan. These districts cover 40,000 sq. miles and contain 59 mines:—25 copper, 27 silver, 6 gold and one *tin mine. Of* the net profits of the company, 10% is to be paid to the Provincial



India.—The quantity of gold produced from the Kolar field during 1902 was 513,220 oz. crude gold, valued at £1,959,268, as compared with 504,732 oz. valued at £1,921,000 in 1901. During the year the Government works for supplying electrical power to the mines was completed, and the full 8,000 H.P. will soon be available. Of the 15 operative companies in the Mysore district, five paid dividends amounting to £874,158, five produced gold but paid no dividends, while five were non-producers. The Coromandel, Nine Reefs, and West Balaghat mines are no longer producers; the first of these, however, will probably resume crushing in 1903. The production of gold decreased considerably during April, May and June, 1902, due to the scarcity of water. At the Hutti (Nizam's) Gold Mines, Ltd., at Hyderabad, a 10-stamp mill has been erected. The report of the Champion Reef Gold Mining Co., Ltd., for the fiscal year ending September 30, 1902, shows an income from the sale of gold of £571,705, and a total income of £543,326 after deducting the royalty paid to the Government, as compared with £576,329 in 1901. The expenditures amounted to £259,489, leaving a net balance of £288,293, out of which £130,075 in dividends were paid, or at the rate of 110%. The quantity of ore crushed amounted to 134,088 tons yielding 138,872 oz. bar gold, an average yield of 1 oz. 17 gr. per ton, while the tailings and slimes amounting to 115,411 tons treated by the cyanide process, yielded 11,873 oz. bar gold, an average of 2 dwt. 1 gr. per ton. The total production of bar gold was 150,745 oz. A new 120-stamp mill was placed in operation. The scarcity of water during the dry season (April to July) caused a large decrease in the output. A new cyanide plant with a capacity of 8,000 tons of tailings per month was started in August, which increases the total capacity of the plant to 20,000 tons of sand per month. The Mysore Gold Mining Co., Ltd., during 1902 milled 140,306 tons of ore yielding by amalgamation 154,905 oz. bar gold, an average of 1 oz. 2 dwt. 2 gr. per ton. The cyanide works treated 114,549 tons of tailings, from which 12,927 oz. gold were obtained, an average of 2 dwt. 6 gr. per ton. The plates yielded 672 oz., making a total output of 168,504 oz., as compared with 164,581 oz. in 1901. The gold realized £657,918, upon which £32,610 in royalties were paid. Receipts from various sources amounted to £3,131. Expenditures amounted to £253,704, and £341,500 were paid in dividends, a rate of 130% for the year. The balance on hand at the end of the fiscal year was £376,145. Since January, 1898, the company has paid £3,175,152 in dividends on a capital of £265,000. In November, 1902, the capital was raised to £290,000 by the issue of 50,000 shares of 10s. each, 15,000 of these shares and £20,000 being paid to the Gold Fields of Mysore & General Exploration Co., Ltd., for their 342-acre block. The capacity of the cyanide plant is 15,000 tons of tailings per month. The new 60-stamp mill was started in October, which increases the total number of stamps to 210; of these, 150 are operated by electric power. The ore reserve is estimated to be over 340,000 tons. The Ooregum Gold Mining Co., Ltd., milled 106,930 tons of ore during 1902, yielding 88,069 oz. gold valued at £327,846. The ordinary expenditure amounted to £164,675, and the profit to £148,937. *The mills* contributed 68,942 oz., the cyanide works 16,239 oz., and 2,888 oz. *were obtained* from skimmings, dismantling old mills, etc. The new 120-stamp



is an indication of what may be hoped for in mining in the temperate zones of the Far East.

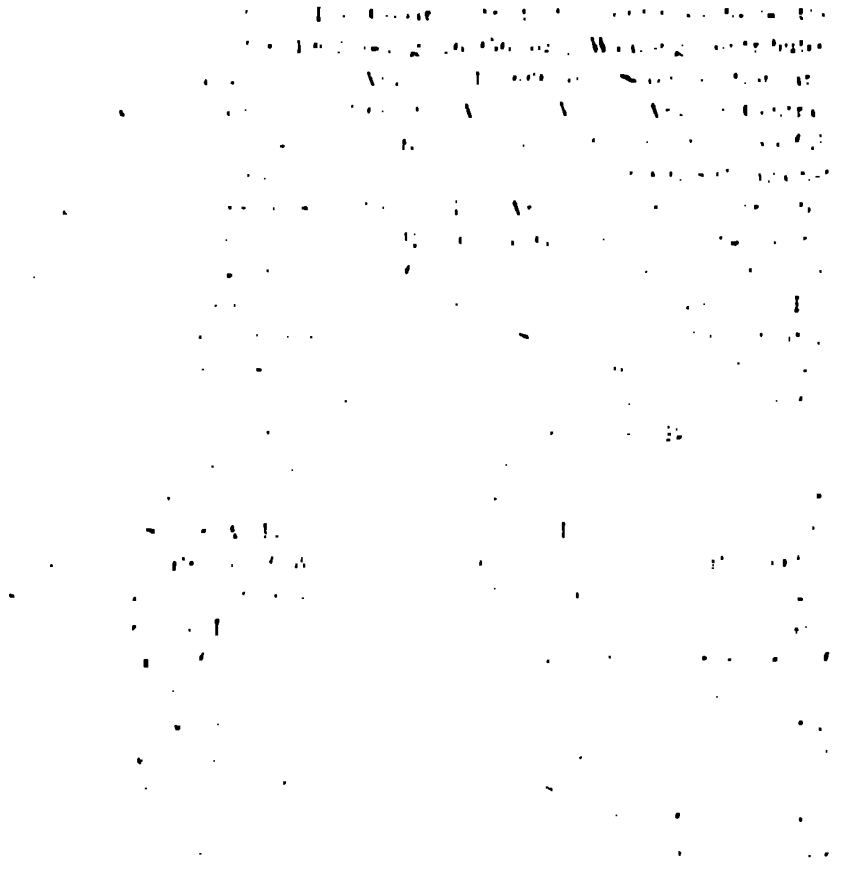
Malay Peninsula.—The output of gold in Pahang in 1901 amounted to 23,948 oz., valued at £77,831, as compared with 17,048 oz. (£65,229) in 1900. The Kedana Co., which owns a mine near Mt. Ophir, Malacca, has erected a mill and has crushed ore for six months of 1902. The mill at Ketchau was not in operation during the greater part of the year, as it had no ore to crush. The Punjum Gold Mining Co. and the Tin Concession & Batu Bersawah Mining Co. are still prospecting. The Raub Australian Gold Mining Co. increased its output from 12,477 oz. in 1900, to 18,901 oz. in 1901. Four companies began exporting gold in 1901—the Malaysian Mining Co., 1,315 oz.; Queensland Raub Syndicate, 75 oz.; Malaysian Mining Co., 1,164 oz., and Bentong, 114 oz. In the Bentong mine a shaft was sunk 105 ft., but no defined lode was discovered; at the Raub mine samples assayed 11·5 dwt. gold. No deep shafts have been sunk; it is not known, therefore, if any of the mines continue in depth. The country is covered with heavy jungle, transportation facilities are inadequate, and means of communication are lacking, and although alluvial deposits are known to exist from Budu to Sepan, from Benta to Lipis, and along the Semantan and Krau rivers, and the tributaries of the Jelai River, the deposits have not been worked.

AUSTRALASIA.—(Through the courtesy of F. Danvers Power, special notes on the mining industries of the States have been incorporated in the following review.)—The year 1902 was one of depression throughout Australasia, principally on account of the low price of metals and the prevailing drought. The latter has acted directly by forcing certain mining operations to cease temporarily for want of water, and indirectly by its effect on the general prosperity of these States, inasmuch as the wool clip was a failure and the output of wheat did not suffice for domestic consumption, so that export was out of the question. Mining legislation did not encourage the investment of foreign capital. Despite the baneful effects of the drought development work has been carried on actively in some cases. That the present depression is not due to anything radically wrong with the mines themselves is indicated by the increased yield of gold in the principal States over that of last year, and the fact that other mines are ready to recommence work as soon as the prices of copper, lead and silver rise, or a sufficient supply of water is obtained. The combination of adverse conditions has caused a few mines to try to meet them by increasing their output with the same management, while being satisfied with smaller profits. By this means,

PRODUCTION OF GOLD IN AUSTRALASIA.

States.	1900.		1901.		1902	
	Fine Oz.	Value.	Fine Oz.	Value.	Fine Oz.	Value.
New South Wales	281,616	$5,821,003	216,888	$4,483,076	254,435	$5,259,171
New Zealand	339,395	7,015,293	412,875	8,534,126	458,933	9,486,145
Queensland	677,024	13,994,086	598,382	12,368,556	640,463	13,239,370
South Australia (a)	19,376	400,502	21,946	453,624	24,082	497,775
Tasmania	74,552	1,540,990	69,491	1,436,789	70,996	1,467,487
Victoria	752,284	15,549,710	730,449	15,098,390	720,867	14,900,309
Western Australia	1,354,343	27,994,270	1,669,072	34,799,718	1,819,308	37,605,038
Totals	3,498,590	$72,315,854	3,719,103	$77,174,268	3,999,083	$82,454,894

(a) Includes Northern Territory.



£53 10s. per week. The total dividends paid by New Zealand mines, but not including the West Coast, during 1902, amounted to £145,967. On the West Coast 44 dredges produced 30,000 oz. gold, valued approximately at £120,000. Hydraulic sluicing is receiving increased attention, both in the Otago and West Coast districts. The Waitekauri Gold Mining Co., for the year ending May 31, 1902, produced 55,413 oz. bullion, valued at £46,728. The New Zealand Crown Mines Co., Ltd., during the year ending August 31, 1902, treated 32,561 tons of ore, obtaining 16,991 oz. gold and 13,266 oz. silver, valued at £74,238. The expenditures amounted to £53,521, leaving a profit of £20,717, which, with £5,236 brought forward from previous account, gave a surplus of £25,953, out of which a dividend of £15,000 was declared. The balance carried forward was £10,203. The 60-stamp mill now in operation is to be enlarged for 20 additional stamps. The Waihi Gold Mining Co., Ltd., during 1902 treated 179,487 tons of ore, yielding gold bullion valued at £520,138, and a dividend of £250,000 was paid. The company acquired the mines and 40-stamp mill owned by the Union-Waihi Co., so that it now operates 330 stamps. It is converting its dry crushing into a wet crushing plant. On the average 17,000 tons per month are crushed, and when all the stamps are converted the capacity will probably be raised to 20,000 tons per month. The Progress mine treated 55,976 tons of ore, yielding £106,996, the expense being £44,670, leaving a profit of £62,526. An important discovery of gold is reported from Kawhia, where the Government has withdrawn the land from sale on the ground that it contains minerals. All kinds of mining machinery in this colony are driven by electric power generated by the water supplied by rapid streams and rivers, the current in many cases being carried a considerable distance. The cyanide process has now been introduced in the Hauraki gold fields with an 85 to 90% extraction, where formerly an extraction of only 65% was obtained by amalgamation. The New Zealand Government, having bought the patent rights to the cyanide process from the Cassel Gold Extraction Co., received £4,577 as royalties for the fiscal year ending March 31, 1902. As soon as the Government is paid a sum equal to its outlay for the patent rights, all royalties will cease.

Queensland.—The dividends paid by the Queensland mines in 1902 amounted to £987,541. The report of the Mount Morgan Gold Mining Co., Ltd., for the year ending May 31, 1902, shows an output of 213,907 tons of ore, 120,641 tons of which were oxidized ore and 93,266 tons were sulphide ore. The plant treated 232,953 tons, 19,046 being tailings, and obtained 147,628 oz. gold valued at £570,337. The total income was £574,573, and expenditures £313,690, leaving a profit of £260,883. To this is to be added £22,279 brought forward from the previous year, making a total of £283,162. Dividends of £204,167 were paid, leaving a balance to be brought forward of £78,995. The cost of treating the oxidized ore was $2·68 per ton, and the sulphide ore $4·07 per ton. The Charters Towers mines for the year 1902 produced 378,194 oz. gold, against 336,431 oz. in 1901. The dividends paid by the various companies amounted to £115,564 in 1902, against £319,941 in 1901. The New Queen Gold Mining Co., *Ltd., for the* year ending August 31, 1902, treated 2,889 tons of ore, obtaining by *crushing* 3,367 oz. gold, valued at £11,359, and by cyaniding 1,044 oz., valued at

yielding 11,681 oz. gold and 341,346 oz. silver. The total cost of treating the ore was $4·73 per ton, as compared with $5·10 in the preceding half year. The metal obtained was valued at £268,569; the total receipts were £284,325, and expenditures £207,211, leaving a net balance for the half year of £77,114. The company has absorbed the Mt. Lyell Reserve copper and gold mines, the Glen Lyell copper mine, South Tharsis flux mine, Royal Tharsis and the King Lyell mines.

Victoria.—The gold in this colony was obtained both from alluvial workings and from lode mining. Of the seven districts, Ballarat and Bendigo still continue to be the largest producers of gold, their output amounting to about two-thirds of the total yield. The output of gold in Ballarat in 1902 was 62,712 oz. gold. The Long Tunnel Extended, Walhalla, is the most productive mine. On January 1, 1902, there were 27,777 men engaged in gold mining, 12,886 of them working on the alluvial deposits, and 14,891 working in the quartz mines. The receipts of the Melbourne branch of the Royal Mint during 1902 amounted to 1,016,682 oz. gold. By an act of the Government all gold buyers are obliged to take out a license.

Western Australia.—There was a large increase in the production of gold in this colony in 1902, the mines treating 1,888,950 tons of ore for a yield of 2,117,241 oz. gold, as compared with 1,572,951 tons of ore yielding 1,841,498 oz. gold in 1901. The gold entered for export or sent to the Perth Mint in 1902 was 2,177,442 crude oz., or 1,871,037 fine oz., valued at £7,947,662, as compared with 1,703,417 fine oz., valued at £7,235,653 in 1901. The greater portion of this output was obtained from the Kalgoorlie district, but there were substantial increases in the output of the Murchison, East Murchison, Mount Margaret and North and East Coolgardie; many of the other gold fields showed a decreased output, especially the gold fields from Peak Hill northward. In the Ashburton, Gasgoyne and Kimberley fields the alluvial deposits are being worked out, and at Pilbarra and West Pilbarra the workings have reached water level and the mine owners, having no capital to provide for machinery for sinking deeper, have had to abandon their properties. The Phillips River gold field, which was declared in 1901, has developed slowly, owing to the absence of crushing facilities, but several batteries are now being erected. The cost of mining in the Kalgoorlie district has been steadily reduced, and will be further reduced as the Coolgardie water works are now completed. These works bring water to a district 1,300 ft. above and 350 miles from the source of supply by means of 8 pumping stations, and supply daily over 6,000,000 gal. of water. The Government operates several batteries and cyanide works to enable miners to treat their ores independently of the large mines. According to Mr. Alfred James the roasting (called the Marriner process in Western Australia) and Diehl processes have been successfully employed on the telluride ores at Kalgoorlie. On low-grade ores, roasting is not required, but with rich ores, the ore must first be roasted and then bromo-cyanided. At the Great Boulder Main Reef mine an extraction of 90% has been obtained with this process, at a minimum cost of $5·25, and an average of $6·25 per ton for the year. On the richer ores of the Hannan's Brownhill and Lake View mines the cost was $8·19 per ton.

Progress in Gold Milling during 1902.

By R. H. Richards.

Gold Milling.

Stamp Mill Construction.[1]—J. J. Deming discussed this subject in an inte ing manner, the following being a few of the observations made: The *knee frame,* while it has some faults, is considered best for a battery fr The *iron battery frame* has gradually come into general use in Aust experience having shown the fallacy of the idea that the iron work be crystallized by repeated shock. No serious effects have resulted in using iron frames for years. The *mortar* should be designed to suit the *i.e.,* along the lines of inside amalgamation, or speed of crushing, or It is better to put more metal in the *stem* and less in the *boss-head;* with a *tappet* there is less vibration in the stem and consequently longer life; wi steel tappet, and the end of the cam chilled, there will be less friction and wearing of cams. *Shoes* and *dies* should not be of the same hardness; best results being obtained with steel shoes and chilled cast iron dies. *Stu* vary in weight up to 1,250 lb. according to the work to be done. It has demonstrated at the Alaska-Treadwell mill that a stamp heavier than 1,00 is a good pulverizer, but not a good amalgamator. For rapid crushing, order 1, 5, 2, 4, 3 will work well, while for the long, slow drop, the order, 1, 2, 4 will give an even distribution of the ore in the battery. The order 1, 5, 3 for heavy stamps and inside amalgamation will give good results. order, 5, 1, 3, 4, 2, commonly used in Australia, is a very good system. order of the drop, however, is more or less a fancy of the mill man; rarel two use the same order. *The Muntz metal plate,* 60% copper and 40% zinc, in Australia is in some instances superior to the silver-plated copper plate, b more easily cleaned as verdigris is absent, but its absorbent power for mer is limited. In general, the silver-plated copper plate is considered to be sup to all others.

Mortar Foundations in Oregon.[2]—According to W. H. Washburn, it bec necessary to place at a mill in Oregon a set of mortar blocks on what is know webfoot, *i.e.,* a sort of indurated clay. The pits for each 10 stamps were 3 ft. wide × 13 ft. 2 in. long × 20 ft. deep. Beginning 3 ft. from the bottom, pit was undercut at an angle of 45° to a point level with the bottom and un cut 1 ft. at the ends. A layer of sand was spread over the bottom, and a of timbers 10×12 in.×7·5 ft. was laid crosswise, being well pounded down leveled. On these were laid lengthwise three timbers, each 10×12 in.×14 long and a series of 2-in. planks was spiked lengthwise along the row to prevent the presence of sand between the timbers, and also to serv an additional binder. The upper surface of the timber was made level and mortar blocks put in place. The blocks were built of 2·5-in. plank, 24 ft. l one layer being of three planks, each 10 in. wide and the next of two pla each 15 in. wide, in alternate layers. These foundations have proven satisfact *and no settling* was noticed after a three weeks' run. (See Fig. 1, on next pa

[1] *Mining and Scientific Press,* Vol. LXXXV., (1902), p. 188.

[2] *Ibid.,* Vol. LXXXIV., (1902), p. 246.

Morison's Open-Front Mortar Box.[6]—The front of the mortar in the Morison box is entirely open from the discharge lip upward; that portion of the box above the screen opening being closed by means of a removable pressed steel door, which is dished and flanged for strength and rigidity; when closed the end flanges seat themselves upon suitable ledges on the main casting and are secured thereto by studs fitted with wing nuts.

Theory of the Patio Process of Amalgamation.[7]—Miguel Bustamente, Jr., calls attention to the difficulties experienced in extracting the gold from Mexican ores composed principally of decomposed iron pyrites in quartz with native gold in irregular grains; the metallic value in some portions, however, being in calcite and siderite. At first the extraction of gold by amalgamation from 1-oz. ore was about 10%, and was attended with an excessive loss of mercury. Direct amalgamation combined with cyaniding of the concentrates gave an extraction of 32%. Occasionally during amalgamation, the odor of hydrogen sulphide gas was noticed, which accounted for the great loss of mercury. A preliminary roasting and washing of the ore raised the extraction to 63%, with a mercury loss of 11%. Upon investigation, the gold which had escaped amalgamation was found in a spongy state, similar to "platinum sponge," and in contact with the mercury it caused an energetic electrochemical action, which decomposed a relatively large quantity of water; the oxygen set free being absorbed by the sponge while the hydrogen combined with the sulphur of the pyrite, and produced hydrogen sulphide of which a part escaped and a part attacked the mercury causing the heavy loss of the metal. The actual chemical reactions are quite complicated, but the formation of mercury sulphide was proved by an analysis. The loss of gold is explained thus: Whenever the sponge or black gold is present under such conditions that it will act as the electro-positive element, it will receive, condense, and hold oxygen which will be returned when the gold is made the electro-negative element of the couple. Mr. Bustamente perfected a method by which the loss of mercury was reduced to 0·03%, and the extraction of gold raised to 95% of the assay value, at the low cost of $0·42 per ton for crushing, and $0·19 for amalgamation, including the electric current. At first the ore was roasted in a reverberatory furnace and washed abundantly with water; it was then passed through the mortars where it was pulverized and the amalgamation begun. The mortars were fitted with inside plates, connected with the poles of a dynamo that produced a current of 150 amperes and 14 volts. The two stamp batteries discharge into a common channel, in which, side by side, were placed the large amalgamating plates, one connected with the positive pole, and the other with the negative; an arrangement which gave encouraging results; but, in view of the energetic decomposition of water, the electro-motive power was lessened by subdividing the amalgamating plates and uniting them in parallel, thereby diminishing the liberation of gases and reducing the loss of mercury to an insignificant quantity. Similar arrangements were made for the pans and the washers. An average of 9 tons of ore was treated in 24 hours with an

[6] *Engineering*, Vol. LXXIV., (1902), p. 145.

[7] *Transactions of the American Institute of Mining Engineers*, November, 1901.

[illegible] of the gold. The preliminary roasting was abandoned later, [illegible] good extraction of this was obtained.

[illegible]. At the Commonwealth mill at Pearce, the ore consists [illegible] of decomposed quartz and talc carrying silver chloride and free gold, [illegible] a Blake breaker and roughing rolls, thence it is passed to 80 [illegible] weight which drop 105 times per minute, and crush 240 [illegible] through a 30-mesh screen. There are no blankets or plate amalgamation, [illegible] going direct to settling tanks and thence to the amalgamators. [illegible] are impounded for future treatment. Crude oil is used [illegible].

[illegible]. At the Port and mine, Cripple Creek, the fine [illegible] separated by screens, the coarse portion, which constitutes [illegible] being hand sorted. Formerly the fine material with a value [illegible] 6c per ton was rejected, but at present a saving of 90% of the [illegible] effected by a simple washing process. The water concrete [illegible] plate perforated with holes 1/16 in. in diameter, on the [illegible] numerous jets of water impinge in various directions [illegible] which removes the dry fines. The coarser portions [illegible] the waste [illegible] then passed over the perforated plate, [illegible] washed [illegible] and collected and dried [illegible]. The small quantity of water [illegible] a 5-ton feed pump operated by exhaust steam. In [illegible] waste is passed [illegible] average of about 6c per ton.

[illegible] with flint [illegible]. The Waihi New [illegible] Mill at Kirk, has been [illegible]

[illegible]

[illegible]

[

essentially free milling, and carries 1% of sulphides in a quartz gangue, the g being coarse. Hand breaking is the common practice except in three mi where Gates breakers are in use. The lack of uniformity resulting from h breaking is given as the cause of the low efficiency per stamp. Hand feedi is used except in four mills equipped with mechanical feeders. The cost of local mechanical feeder is $121·75, while the cost per day of feeding 10 stamp by hand is from $1·22 to $1·46. The mortar boxes weigh from 2 to 3·25 tons the bottoms being 5·5 in. thick. No liners are used, because the ores being mainly custom, their removal at the frequent clean-ups would entail too much labor; therefore, the box is of greater thickness than usual. Inside copper plates are not used. The discharge is vertical, and with new dies is less than 3 in. in depth, sometimes being but 1·5 in. Chock blocks are not used, and the height of discharge increases with the wear of the dies. Punched screens with from 12 to 16 holes per linear inch are generally used. The stamps weigh from 600 to 1,000 lb. The average height of drop is from 6 to 8 in. with from 75 to 80 drops per minute. In each head of five stamps, the middle stamp drops first, and both end ones next. The stems are of best hammered iron generally 12 ft. long and from 2·75 to 3·125 in. in diameter. With one exception screw tappets are in use. The weight in the stamp is distributed approximately as follows: stem, 43%; head, 23%; shoe, 25%; and tappet, 9%. In all cases the cam shaft is driven by gearing. The "horse" battery frame is most common although in a few of the smaller batteries the "A" frame is used. The frame is generally constructed of wood although sometimes of cast iron. The reason for the use of the horse frame is that the cam shaft being driven by gearing necessitates the counter shafts on the same level. The output per stamp per 24 hours averages but 2 tons, the low efficiency results from the absence of breakers and automatic feeders; however, the mining conditions in Bendigo do not require a maximum output. The main ore supply is not sufficient to keep the mills in continuous operation, and it is supplemented by custom ore. While increased capacity per stamp would reduce labor charges per ton, it would involve increased first cost which is not warranted by existing financial conditions. Clean-ups are made weekly, the retorted gold being sold without refining. The copper plates of an average length of 10 ft. are inclined 1 in. per foot, and have several steps with a riffle between each set. In a few cases the last plate is not amalgamated. Mercury is fed into the mortar at regular intervals from which a large portion of the total amalgam is obtained. The loss of mercury per 100 tons of ore averages one pound. The plates are usually sealed every six months by being heated to redness; this oxidizes the copper and causes spots to form, which tarnish readily, and require constant attention. To within 18 months ago, concentration by blanket strakes and Halley tables was common. Recently, however, Wilfley tables have been introduced. Apparently but little attention is paid to the production of clean concentrates as they contain 50% silica. The concentrates are roasted and amalgamated in crude pans. At one plant the cyanide process is used.

Mill Practice at the Kalgurli Gold Mines, Limited.[13]—The percentages of gold

[13] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 51.

California, the distribution of the gold as caught in the sluice boxes, 6 ft. wide × 4·5 ft. deep × 12 ft. long was:—

	Boxes.	Per Cent.
First section	15	73·6
Second section	30	13·4
Third and fourth sections	71	1·6
Undercurrent	.....	11·5

Under the conditions that prevailed a long sluice was unnecessary, the coarse gold being caught in the first boxes, and the fine in the undercurrent. The gravel averages from 4 to 6c. per cu. yd., and from 2·5 to 3 cu. yd. of material were moved per miner's inch of water at a total cost of $0·08219 per inch.

A "Crown Gold" Dry Concentrating Plant.[17]—The capacity of the 80-ton concentrating plant of this type which has been erected at Tintic, Utah, is claimed to be fully up to the requirements.

Dry Blowers in Australian Gold Placers.[18-19]—According to B. Dunstan, the types of dry blowers in use at the Clermont gold field are constructed on three principles: (1) the separation of the larger pebbles from the finer portion by a coarse punched plate; (2) the delivery of the material which passes through the coarse screen to a fine punched plate; and (3) the forcing through the screen of a blast of air sufficiently strong to remove the earthy particles, but not the gold. The machines are not suited to clayey earth, although this difficulty can sometimes be overcome by heating the earth and then powdering it on a flat sheet. The losses of gold are generally due to the presence of clay. Fans are not suited for producing the blast as it must be pulsating. The cost of a machine varies from $32·50 to $50, and the daily capacity under normal conditions is from four to five loads. Dry jigs also are used successfully on gravels carrying coarse gold.

The Placers of La Cienega, Sonora, Mex.[20]—R. T. Hill calls attention to the importance of underground water in arid districts.

Hydraulic Practice in Oregon.[21]—In Josephine County, along the Illinois River, ground sluicing is being replaced by hydraulic operations on a large scale. The gold is coarse, and is generally saved by the ordinary pole or block riffles in the sluices.

Gold Dredging.

Recovery of Fine Gold from Snake River Sands.[22]—Robert Bell states that the fine gold in the Snake River placer beds is recovered on a commercial scale up to 95% of the gross content of the gravel. The fine material after separation from the coarser gravel by passage through a screen-floored sluice box, is concentrated by gravity on burlap tables, the gold in the small quantity of concentrates being collected by mercury in a clean-up barrel. This method is simple efficient and adapted for operation on a large scale.

[17] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 22.
[18-19] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 482.
[20] *Ibid.*, Vol. LXXIII., (1902), p. 132.
[21] *Ibid.*, Vol. LXXIV., (1902), p. 582.
[22] *Ibid.*, Vol. LXXIII., (1902), p. 241

Platinum Washing in the Urals.[21]

According to L. St. Rainer, it is necessary to use a large volume of water in washing the clayey gravels, and mechanical agitation is also required in order to disintegrate the material. In one intsance a trommel 3 m. long, 1 m. diameter at the feed end, and 1·6 m. diameter at the outlet is used. It is made of strong iron plate perforated with 15-mm. holes. A strong stream of water is played into the trommel which revolves slowly, the fines passing through to the washing apparatus below. It is necessary to treat tough gravels in a "boronka" in order to free the rich sands. A boronka consists of a third of a conical trommel made of cast iron plates, having suspended stirrers which are given a slow backward and forward motion, thereby causing the gravel to be gradually passed along to the discharge end. The stirring combined with the strong streams of water thoroughly disintegrates and washes the gravel so that the discharged material is practically free from rich sands. In the Plast district, however, the gravel requires even a more thorough stirring, and for this purpose a "tschascha" is used, which consists of a cast-iron cylindrical tank 2·1 to 3·5 mm. diameter, containing a six-armed stirrer revolved by a central vertical shaft. Attached to the arms are vertical iron bars which disintegrate the clayey pulp. The bottom is made of three cast-iron sectors with conical holes 15 mm. diameter at the top. One of the sectors is fitted with a gate or trap so that from time to time the tailings can be discharged. A machine of this type 4·16 m. in diameter, the arms making 25 revolutions per minute, requires 13 H.P. to operate, and has a capacity of 40 tons of clayey gravel per hour; from five to ten volumes of water per volume of sand is required for successful work. The washed material passes direct to the riffle tables from 8 to 13 m. long having 44-mm. riffles, 265 mm. apart; the grade is from 13 to 16%. The upper portion of the table is covered with linen or felt protected by a wooden grate. When necessary the tailings are elevated by a machine of the Archimedian screw type. Washing is carried on continuously for 11 hours when the feed is stopped, the riffles removed, and the concentrates carefully washed on the table until reduced to one-third the original bulk. The concentrates are then shoveled into buckets and rewashed on a smaller table until there remains only a fine gray slime, which subsequently is worked on a plane surface with a brush, the gold being extracted with mercury. The tailings are washed in sluices, and the resulting concentrates treated as described above. In working a gravel carrying 2·6 g. metal per ton, the loss by washing was 0·27 g. per ton, while that by theft amounted to 0·43 g. per ton, making a total of 27% of the metal content. It would seem that improved methods especially of classification would give more satisfactory results.

[21] *Berg- und Huettenmaennisches Jahrbuch*, Vol. L., p. 255.

the tailings. The strongest solution, which runs lowest in gold, assays 10c. per ton after precipitation. The total quantity of zinc available for precipitation is from 100 to 120 cu. ft. The precipitates obtained vary in value and quantity, the bulk of the values coming generally from the short coppery shavings removed each month. These shavings are treated with sulphuric acid, and the sludge washed, dried and roasted with gentle rabbling. It is then returned to the acid tank and again treated with dilute acid, and in this way the great bulk of the copper removed. The coppery washings after thorough settling are run to waste over scrap iron. The precipitates after this treatment are then clean enough to be cast into a brick of base bullion.

The entire water supply is drawn from the Colorado River, 12 miles distant, at a cost of approximately 2c. per ton of ore treated. The leaching vats are sluiced out, by pressure furnished by a steam pump, in from 3 to 4 hours, through four 16-in. square gates. The average value of the tailings treated approximates $1·40 per ton, the residues assaying 40c. to the ton, making an extraction of 71·4%. Material of $1 per ton in value has been treated with a small profit at the plant.

Successful experiments are being made at some of the Mother Lode mines in the treatment of raw concentrates by the cyanide process. The concentrates are ground to 100-mesh size or finer, and then agitated.

The largest plant in the State is that of the California King Gold Mining Co., at Picacho, in San Diego County, near the Arizona line. It has a capacity of over 750 tons per day, and although constructed in 1901, it has not yet become operative.

Colorado.—A few new mills have been constructed, mainly of small capacity, the principal one being that of the Tobasco Mining Co., near Lake City, Hinsdale County. Some plants have been projected to treat Cripple Creek dumps, and one or two small ones have been built which are said to operate successfully on $4 to $5 material when it is suitable. One of these plants is treating the dump of the Pharmacist mine, and another is soon to be erected in the district by Temple & Crumb, of Colorado Springs, which is to crush coarse, and have a capacity of 50 tons per day. The cyanide plants of the Liberty Bell and Smuggler-Union mines near Telluride, have been in operation during the year, as well as the Gold Run cyanide plant, which treated old accumulated tailings from the Tomboy and Smuggler-Union mines. The cyanide tailings plant of the Camp Bird mine, near Ouray, has also been in operation.

The cyaniding of the Cripple Creek milling ores has received a serious check on account of the preference for chlorination, the Dorcas mill at Florence being the only cyanide mill in continuous operation. This mill has installed the Begeer pneumatic cyanide process, which consists essentially in passing the cyanide solution from the extractor boxes (after standardizing) repeatedly through a centrifugal pump, provided with suitable pipes and cocks to allow the absorption and mixing of air with the solution to the fullest extent, thereby causing the solutions to absorb a maximum quantity of oxygen.

At Colorado Springs the Telluride Reduction Co. has erected a bromination plant, in which it is intended to treat the dust by the Riecken process.

plant using the pneumatic process has been erected at the Gold ... at Idaho Springs.

... at the Smuggler-Union mine is described by Mr. William H. ... The plant was designed and built by F. L. Bosqui in 1901, ... in 1902. There are 16 leaching tanks arranged in ... tanks, one above the other for double treatment. The upper ... ft. and the lower, ... ft. made of California redwood and ... of tailings, the daily capacity. Each tank gets a 16-day treat- ... ore to the plant by tramcars, and the tailings are charged ... Brown & Mein distributors. Overflow gates carry off the ... of the ore is regulated by the height of the column of ... regulated by the overflow gates. It has been found, that ... of the deposited tailings pass a 150-mesh screen, about ... at which the tailings will leach satisfactorily. However, as ... possible without impairing the leaching, must be settled. ... 24 hours the tank is then allowed to drain as dry as ... added, and a waste solution applied ... a high percentage alkalinity distributes the lime ... and is applied for 24 hours, after which it is displaced ... to a ... the ore for 24 hours and it is ... are dried for shoveling into ... vacuum until 1% moisture ... the weak solutions ... after the 24 hour con- ... gold. The weaker solutions ...

A canvas plant has been installed, in which the overflow slimes from the mill amounting to about 30% of the ore crushed, are handled by contract.

According to Mr. Charles A. Chase,[2] of the Liberty Bell cyanide plant, the cost of cyaniding at that plant on a 4,700-ton per month basis, is as follows:—

Labor.	Cents Per Ton.	Supplies.	Cents Per Ton.
Foreman	1·5	Cyanide	17·2
Solution men	6·7	Zinc	3·0
Laborers	6·8	Lime	5·2
Assays	2·5	Miscellaneous	0·5
Repairs	0·4	Sulphuric acid	0·3
Labor	17·9	Supplies	26·2
		Total labor and supplies	44·1

The Tobasco Mining Co. erected a mill at Lake City, which is described by Smith McKay,[3] of Denver. The rough crushing is done by a 10×15-in. Dodge crusher, the product from which passes to 36×16-in. rolls for the coarse crushing. The ore is fine crushed by two 30×6-in. high-speed rolls. The screening is done by flat impact screens, the final screens having 8-mesh wire cloth. The product from the screens passes to three Bartlett concentrating tables, which separate out concentrates consisting mainly of iron sulphides amounting to from 1 to 2%. The tailings from the tables pass to a tank, and from this to a revolving distributor over the leaching vats. The slimes overflow from the vats and are discarded. There are six 18×5-ft. leaching vats, three 10×12-ft. solution tanks, two 8×10-ft. gold storage solution tanks, all of steel. Precipitation is done in zinc extractor boxes by zinc shavings. Electric power is used at the mill, being transmitted over a distance of 8 miles. A 75-H.P. motor runs the crusher, elevator, screens and rolls, and a 5-H.P. motor the three Bartlett tables. A 20- and a 5-H.P. motor operate three triplex pumps for solutions and water supply.

Idaho.—No new cyanide plants of any size have been erected, although several have been projected, namely, in Shoshone and Lemhi counties. The plant of the De Lamar Co. in Owyhee County, has treated 35,400 tons of ore, valued at $12·24 per ton. The costs amounted to $2·70 per ton, with an extraction of 84·2%. The cost of treating 22,900 tons of old tailings in cents per ton, was labor, 62·42c.; chemicals, 88·53c.; fuel, 15·46c.; supplies, 12·70c.; assaying and express, 5·10c.; total, $1·8421. The average value of the tailings was $3·97 per ton, and the extraction 69·7%.

Montana.—A number of mills have been in steady operation, some new mills have been built and old ones have increased their capacity. The greatest activity is in Fergus County, where, according to Alex. N. Winchell,[4] the following companies are active:—

The Abbey Cyanide Gold Mining & Milling Co., Barnes & King, Kendall Gold Mining Co., McCormack Brothers, Central Montana Mines Co., Great Northern Mining & Development Co., New Year Gold Mining Co.

The Barnes-King and Kendall properties, near Lewiston, are operating on a large scale, the first having a capacity of 240 tons and the latter 350 tons per

[2] Private communication. [3] Private communication. [4] Private communication.

The Central Montana Mines Co., near Lewiston, has a dry crushing plant of 100 tons capacity, but is treating at present only 100 tons per day. The large percentage of slime mentioned treat the ore by direct cyaniding. The ore is crushed and crushed dry to about 0.25 in. size. As a rule, the values are [illegible], but clayey material is occasionally met with, which is [illegible]. I am indebted to Mr. W. J. Sharwood, of Marysville, for much of the information concerning Montana and Nevada.

[illegible] Lewis and Clarke Counties, the plant of the Montana Mining Co., Ltd., at [illegible] has been worked during the year. Six of the seven leaching vats [illegible] agitators for the treatment of slimes by decantation. Two of these vats have also been added to the vats, so that these are [illegible] 25 ft. deep. Charges of 115 tons of slimes were run through [illegible] the original plant has treated over [illegible] tons of tailings, [illegible] for the winter.

[illegible] near Marysville, a 100-ton tailings plant has been in- [illegible] the stored tailings, which are conveyed to and distributed in the [illegible] by a system of 8-in. belt conveyors. The solutions are [illegible] precipitation process in sheet iron plates 6 ft. square placed 1 in. [illegible]. These plates divide the tank into seven tight compartments, and the [illegible] from plate to plate, the [illegible] which acts as the anode being pre- [illegible] which the other acts as the cathode, and re- [illegible] and copper as a sediment from which it is later removed by [illegible].

[illegible] plants of any size have been built in the State, although [illegible] in operation in the Comstock Lode, treating old tail- [illegible]

ring. This product passes to another grizzly, again with 0·5-in. spaces, whose oversize passes to a style H Gates crusher, all the ore below 0·5-in. size going to 300-ton bins, which feed into a Gates revolving dryer, whose product is taken by an elevator to a 4×8-ft. revolving 6-mesh screen. The oversize from this goes to a set of 36×16-in. Gates rolls, the product of which is returned to the screen. The undersize from this screen goes by elevator to two 4×8-ft. 12-mesh revolving screens, whose oversize goes to two 26×15-in. rolls. The product from these rolls is returned to the 12-mesh screens whose undersize goes by elevator to three 4×8-ft. 24-mesh revolving screens. The undersize from these screens is finished product, and goes to a 150-ton bin, while the oversize goes to an extra 26×15-in. Gates rolls, whose product is returned to the 24-mesh screens. The cyaniding is done in nine 24×5-ft. steel leaching vats, each holding 90 tons of dry ore. These vats are charged by cars running on suspended tracks above the vats. The leaching tanks are discharged by shoveling into cars beneath the vats through four 16-in. discharge gates. There are also three 15×9-ft. stock solution tanks, which act also as sump tanks, and three 15×9-ft. gold solution storage tanks. The ore is leached with a 0·3% solution, which is first aërated by compressed air in the sump tanks. The solution is put on from the bottom, to the extent of 25 tons, and allowed to have 12 hours' contact, when it is drained off and is followed by 30 tons of weak solution 0·16% KCN, which is drained continuously. This is followed by 8 tons of wash water, and the sands drained by vacuum until they contain 15% moisture. The total time for one tank from filling to filling is 9 days. Four pounds of quicklime per ton of ore are added at the first crusher. Precipitation is carried on in extractor boxes, 7 compartments, each compartment is 15×9·5 in. in cross section and 16 in. deep. The consumption of cyanide is 0·4 lb. per ton of ore, and the consumption of zinc from 0·25 to 0·30 lb. per ton. The precipitates are shipped to smelters for treatment. The cost of cyaniding is $1·35 per ton.

New Mexico.—Cyaniding has not been very active. The new plant, that of the Last Chance Mining Co., at Mogollon, treat 1,200 tons monthly. It is said on good authority that a 3,000-ton per day plant is projected at Nogal, near the Old Abe mine.

Oregon.—The North Pole and Cougar cyanide mills, at Sumpter, have not been in steady operation. About 18 miles west of Sumpter, the Red Boy mine has a cyanide annex for the treatment of raw concentrates from vanners.

South Dakota.—Great activity has been displayed in building new mills, and four large plants have been erected. The 700-ton Gayville plant of the Homestake Co., or "cyanide No. 2," has been in commission for a few months. The recently completed wet-crushing mill of the Penobscot Mining Co. at Garden City, is in operation with a capacity of 125 to 150 tons per day. The Hidden Fortune Co. is erecting a mill below Deadwood with a capacity of 200 to 250 tons per day, with a probability that another section will be added. The Horseshoe Mining Co. is building a large plant at Terry, wet-crushing to be employed. This mill is to be erected in two sections of 250 stamps each, the second section to be commenced immediately after the first begins operations. The capacity

at other Deadwood will be in the neighborhood of 1,000 tons per day
[illegible] there is under construction, a cyanide annex to
[illegible] of the Jupiter Mining Co. in Blacktail Gulch, with a capacity
[illegible] tons per day, and a small 5-stamp 20-ton wet-crushing cyanide mill,
[illegible] the Golden Crest Mining Co. The Pluma Mining Co. is adding
[illegible] to the old Hawkeye mill at Pluma, and Hall & McConnell have
[illegible] per day tailings plant at Pluma to treat the very low-grade tailings
[illegible] above the main cyanide plant of the Homestake Co. began
[illegible] The old Homestake chlorination mill of the Homestake Co. at Pluma
[illegible] into a dry-crushing cyanide mill, and has been in steady
[illegible] the latter half of the year, with a capacity of about 200 tons
[illegible] These additions to the mills already in operation will give the dry-
[illegible] ing plants in operation in the near future with a chance for an
[illegible]

Name of Mill	Location	Ore Treated Per Day	Name of Mill	Location	Ore Treated Per Day
		Tons			Tons
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] treated shortly, to 125,250 tons per month
[illegible]

[illegible]

with dust, especially in the tank rooms of the newer mills where belt-conveyors are used in charging the vats. This last trouble has been overcome in an ingenious manner by J. V. N. Dorr at the Rossiter plant. Here the ore is removed at the finished-product bin into a trough about 6 ft. long, in which is a screw-conveyor. Just above the trough is a perforated pipe, through which a 0·25% cyanide solution is sprinkled into the finely crushed ore (20-mesh size), to the extent of from 5 to 10%. The screw-conveyor serves to mix the ore and solution thoroughly, and to carry it to a 12-in. belt-conveyor, which, with a short auxiliary conveyor serves to charge the leaching tanks.

The advantages of this device are: 1. That the charging operation is practically dustless. 2. The ore is placed in the tank in such a condition that percolation is easier and much more uniform, channeling is avoided, and more dust can be charged with the ore and still have a leachable product. Another feature of fine dry-crushing which must be taken into consideration with many ores of the district, is the quantity of dust produced in the comminution and collected by the exhaust apparatus. This, in many cases, is too large to permit mixing with the ore without seriously affecting the efficiency of the percolation, reducing the extraction by uneven leaching, and thus necessitating its separate treatment by agitation and decantation. This introduces into the dry-crushing mills that adjunct of the wet-crushing plant, the treatment of slimes, to which the advocates of dry-crushing object, as expensive and cumbersome. Generally the dust is of higher value than the crude ore.

In the case of the Golden Reward plant, the dust amounts to about 4% of the ore crushed, and at the Rossiter plant to about 6 or 7%. In both plants it is treated separately by decantation, while at the Imperial plant, it is charged with the sands into the leaching vats, being mixed with the sands automatically by a conveyor. While, however, the fine dry-crushing system is open to objections, it cannot be said that no unsolved problems confront the metallurgist in the wet-crushing with cyanide solution method. The first of these is the larger quantity of dilute solution to be handled in the mill. The ratio of solution to ore crushed varies between 3 and 4 to 1. The quantity of solution to be handled in a wet-crushing mill is about 1·5 to 2 times that in a dry-crushing mill.

The second is the problem of washing the values from the slimes. This would be simple if enough wash water could be applied, but the quantity necessary is prohibitive, since it would enormously increase the mill solution. One wash water, and in most cases two are not sufficient. In dry crushing it is the general practice to use one final wash water amounting to from 10 to 25% of the ore tonnage, and of this from 6 to 15%, and even more, is discharged as moisture in the tailings, depending on the coarseness of the ore and the use of a vacuum. This practice keeps the quantity of mill solution about constant. In washing slimes, the percentage of water must be increased, and in order to remove dissolved values more than one wash should be employed. This, however, would so increase the bulk of solution that at frequent intervals some of the weaker solutions would have to be run to waste. When the precipitation of the values is good, and it may not be very good with a weak solution, the

below Deadwood, the crushed pulp will pass directly to Butters & Mein distributors placed above the leaching vats, this separation being deemed sufficient to eliminate the slimes, as the crushing will be coarse.

At the cyanide plants of the Homestake Co. the separation is made by a triple set of cones placed in series, the first set at the stamp mills and the other two at the cyanide mills. The first two sets are large flat cones, with no current except that induced by charging at the center and the overflow. The last sets are smaller and deeper, and have a rising current introduced at the bottom, as in the case of the regular hydraulic classifier. Aside from these, the leaching vats are charged by Butters distributors, the overflow at the periphery of the vats passes to waste, the Homestake plants treating sands only.

The pneumatic cyanide process has been introduced at the Pluma plant of the Horseshoe Co., where three 35-ft. tanks are fitted with the pneumatic process, as an experiment. An air pressure of 4 or 5 lb. is put on after the vats are charged, and air forced through the ore for 4 hours. Then leaching is commenced, the time on the pneumatic tanks is 72 hours, while on the other tanks the time is 120 hours. It is, however, questionable whether any benefit is derived from the pneumatic process for the Black Hills siliceous ores, for while the time is shortened, the extraction is not much increased, and difficulty is encountered in discharging the tanks, owing to the network of pipes. The Hidden Fortune and the Hall-McConnell tailings plant also will use the pneumatic process. During the year, some of the plants experimented with the Schilz barium dioxide process, but it was found to possess no advantage for their ores. With the exception of the Homestake mills, which use zinc dust, all mills use zinc shavings. The method of precipitating in barrels or precipitation vats, instead of the compartment zinc box, is finding much favor.

The new wet-crushing plant of the Horseshoe Co., in course of erection at Terry, will have its rough crushing department separate from the mill, and above the stamps. The crushed product from four No. 5 Gates crushers will be conveyed to the main storage bins above the stamps by a belt-conveyor 610 ft. long, which extends the length of the bins, and is provided with a movable automatic discharge tripper to distribute the ore uniformly in the bins. The main bins have a capacity of 7,000 tons, while the ore bin ahead of the crusher has a capacity of 1,000 tons. The mill is being built in two sections of 120 stamps (500 tons) each. One section is to be completed before the other will be started. The stamps are of 1,000 lb. weight, with a 6- to 7-in. drop. Double discharge mortars are to be used with a depth of issue of about 1 in., crushing in cyanide solution through a 20-mesh woven wire screen. The pulp from the stamps is raised by two spiral sand pumps, with two extra ones to act as relays to 4 Klein classifiers, the height of lift being 20 ft. For each 500-ton section there will be 8 sand leaching vats 40 ft. diameter and 5 ft. deep; 16 slime vats, 20×10 ft., 8 gold solution storage tanks, 15×10 ft.; 8 sump tanks, 24×10 ft.; and 4 solution storage tanks, 30×16 ft. There will also be two water tanks 35×16 ft. All tanks are of steel. It is the intention to complete the slimes treatment in one vat, sluicing the exhausted material from it after treatment. The slimes will be agitated with air at 30 lb. pressure by a special arrangement of pipe

The new cyanide mill of the Hidden Fortune Co. is in course of erection a few miles below Deadwood on Whitewood Creek. As in the Horseshoe mill at Terry, the crushing department is separate from the mill. The crushing will be done by a 15×30-in. Blake, and the crushed product conveyed to the stamp bins by a 24-in. belt-conveyor discharging by an automatic tripper into 500-ton bins. The railroad bins above the mill have a capacity of 800 tons. Challenge feeders supply the 60 stamps, which are each of 1,000 lb. weight, making 7-in. drops, 90 per minute. The capacity of the mill will be about 250 tons per day. The mortars will be double discharge, with 1-in. depth of issue. Crushing will be done in a cyanide solution. The pulp from the batteries will go to Butters & Moon distributors, placed over the sand leaching vats, in which overflow gates will carry off the slimes, to the slime vats. The pulp is raised to the distributor by three Frenier spiral sand pumps. The leaching vats will be discharged by sluicing through six 15-in. bottom discharge gates. The five leaching vats are 40×6 ft. There are 4 sump tanks, 3 gold solution storage tanks, 2 stock solution tanks, 7 slime vats—21 tanks in all.

The new Gayville mill of the Homestake Co. is similar to the Lead mill.[5]

Utah.—During the year the Golden Gate and Manning mills have been in operation at Mercur, the latter mill treating old Mercur tailings at a cost of 59 c. per ton. The Annie Laurie mill in Piute County, built in 1901, has been steadily at work and the new mill of the Ophir Mining Co. in Iron County, situated near the Nevada State line, not far from the Horseshoe mill above described, has also been in operation. At the Sunshine mine at Sunshine, the old mill has been remodeled, and a slimes treatment plant installed. The mill has been in operation treating from 100 to 125 tons per day, although it has a nominal capacity of 300 tons per day. Recently the mill was closed for further changes. The process at this mill, which is rather an innovation in slimes treatment in this country, has been described by Mr. M. D. Stackpole.[6] The ore is crushed to 4-mesh size, and the slimes, which are considerable, on account of the talcose and clayey nature of the ore, are separated in a special conically shaped separator, the patent of George Moore. The slimes are agitated in vats by a centrifugal pump, and are separated from the solution by means of four 30-frame filter presses. This is the only plant in this country, as far as I know, that uses the filter press method of treating slimes.

The Midas Mining Co. in the Mercur district, Tooele County, has a cyanide plant in operation treating tailings from amalgamation.

Washington.—Cyaniding has not been active in Washington during the year; the Republic and Mountain Lion mills at Republic have not been in operation.

Cyanide Practice in Foreign Countries during 1902.

Western Australia and New Zealand.—According to Alfred James[7] the Great Boulder Main Reef, the Great Boulder Proprietary, the Hannan's Star, the *Brownhill* and the Perseverance and others, in the Kalgoorli district in Western

[5] *Engineering and Mining Journal*, Jan. 4, 1902. [6] Ibid., July 12, 1902. [7] Ibid., Jan. 2, 1902.

tion) cost $2·34 per ton; 40,108 tons sands (0·84 oz.), cyanided, cost $1·50 per ton; 51,588 tons slimes (0·44 oz.), cyanided, cost $2·46 per ton.

Lake View Consols.—76,571 tons milled (1·58 oz. amalgamated) cost $1·66 per ton; sands cyanided, cost $1·44 per ton; slimes cyanided, cost $1·70 per ton.

Mr. Alfred James, in the article already mentioned, gives the cost at the Hannan's Star mill, which uses the Diehl process, at $5·33 per ton, on 0·4-oz. ore. The same process on the considerably higher grade ores of the Hannan's Brownhill and Lake View Consuls, cost $8·19 per ton, which includes $2 alone for bromocyanogen. The cost at the Great Boulder Main Reef, which uses the roasting process, is $6·25 per ton with an extraction of 90%. Costs in Kalgoorlie are necessarily high, for power costs about $19 per H.P. per month, and water from 80c. to $1·50 per 1,000 gal.

During 1902 in New Zealand 25 of the 26 cyanide plants were in operation.[9]

Wet Crushing and Direct Cyaniding.—Hamilton Wingate[10] describes the direct cyaniding of wet crushed ores at the Waitekauri Extended mine, Maratoto, N. Z., as follows: Formerly the ore was dry crushed and cyanided, but this method was found to be unsuited to the lower level ores and was high in cost. The choice of a satisfactory process depended on a successful method of slime treatment. In this respect the liberal use of lime was found satisfactory. The ore is a hard, flinty quartz carrying finely divided pyrite. The gold content is uniformly distributed in a fine state of division, while the silver is present as a sulphide. The base sulphides comprise 5% of the ore, and the average value of the ore is from 0·3 to 0·4 oz. gold and 1·75 oz. silver. The mortar boxes, which were double discharge for the old dry crushing method, had one discharge closed for the wet crushing, but were still unsuitable, as a large quantity of slime was produced owing to improper dimensions. A higher extraction by cyanide, however, was obtained on slimes than on sands. The ore was crushed through a 40-mesh screen, the classification of 656 tons of ore giving 54·11% sands, and 45·89% slimes; 70% of the total pulp passed an 80-mesh screen, which was the fineness necessary for a good extraction.

The crushed pulp passed to a 5-ft. square pyramid shaped spitzkasten, 5 ft. deep. At the apex was a 2·5-in. cock to regulate the discharge of the sands. A perforated pipe or rose at the overflow end was necessary to prevent the settling of the slimes with the sands. It was essential to make a clean separation of the sands from the slimes, since those slimes that pass with the sands are lost in the overflow from the sand vats, while any sands in the slimes cause a portion of the slimes pulp to set hard at the bottom of the vat, in a mass too tough to be affected by the agitator.

The discharged sands from the spitzkasten passed to a vat into which they were charged by a Butter's distributor, and the overflow of the spitzkasten containing the slimes passed to an agitator vat. The 30-ton sand vats were 20 ft. in diameter and 4 ft. deep. The sands were treated first with a preliminary alkaline wash, then with a weak sump solution, followed by a 0·5% cyanide solution, and finally by the usual washes of strong and weak sump and wash water. The sands in general presented no difficulty of treatment.

[9] *New Zealand Mines Record*, May, 1902.

[10] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

placed close to the bottom and does not revolve fast enough to throw the slime to the surface, but just sufficient to keep the entire mass in suspension and flowing around the tank, leaving a few inches of perfectly clear solution at the top. Compressed air can be blown into the vat to aid in the solution of the gold. The overflowing solution is ready for precipitation. Weak solution and washes are introduced in a similar manner to the strong cyanide solutions.

J. Yates[11] states that in South Africa the cost of a plant for treating slimes by the decantation method is from $750 to $1,000 per head of stamps. An average of 60% extraction by the decantation method on slimes is the best obtainable in South Africa. Led by these facts John R. Williams is to make a test on a working scale, side by side, of the decantation and filter press methods of slime treatment, which will be of very great interest.

The Bromo-Cyanogen Process.—The Diehl process as practiced at some of the Kalgoorlie mines, Western Australia, and already mentioned, is described by H. Knutzen[12] as follows: The process is used at three mines, the Hannan's Star, the Hannan's Brownhill and the Lake View Consols, at the last named mine both the Diehl process and the roasting process were operated. A number of analyses were made on Kalgoorlie ores, from the different mines, with the following results:—

Insoluble matter (insoluble in dilute hydrochloric acid), 40 to 78%; iron carbonate (spar), 10 to 30%; calcium carbonate, 9 to 38%; gold, 0·8 to 5·5 oz. per ton.

It is thought that this composition accounts for the trouble met with in the roasting process, as the finely ground ore after roasting has cement-like properties, forming an iron cement, which sets in the vats. The Diehl process comprises the following essential stages:—

1. Crushing and sliming the ore.

2. Treating the slimes in agitators with a solution of potassium cyanide in combination with cyanogen bromide.

3. Filter pressing the sludge and precipitating the gold from the solution by means of zinc shavings.

According to the nature of the ore, amalgamation and concentration may be added as part of the process.

It was found that in order to get a good extraction on Kalgoorlie ore it must be slimed. Only part of the gold is present in the metallic state, the greater part being present as a telluride and in sulphides. The slimes from the ore are richer than the sands owing to the brittleness of the telluride minerals. Ore was crushed in a battery through a 40-mesh wire screen with this result:—

On 3·25-oz. ore the sands contained 20·27% of the gold value; the concentrates, 38·49%; the slimes, 29·62%; and amalgamable gold, 11·62%.

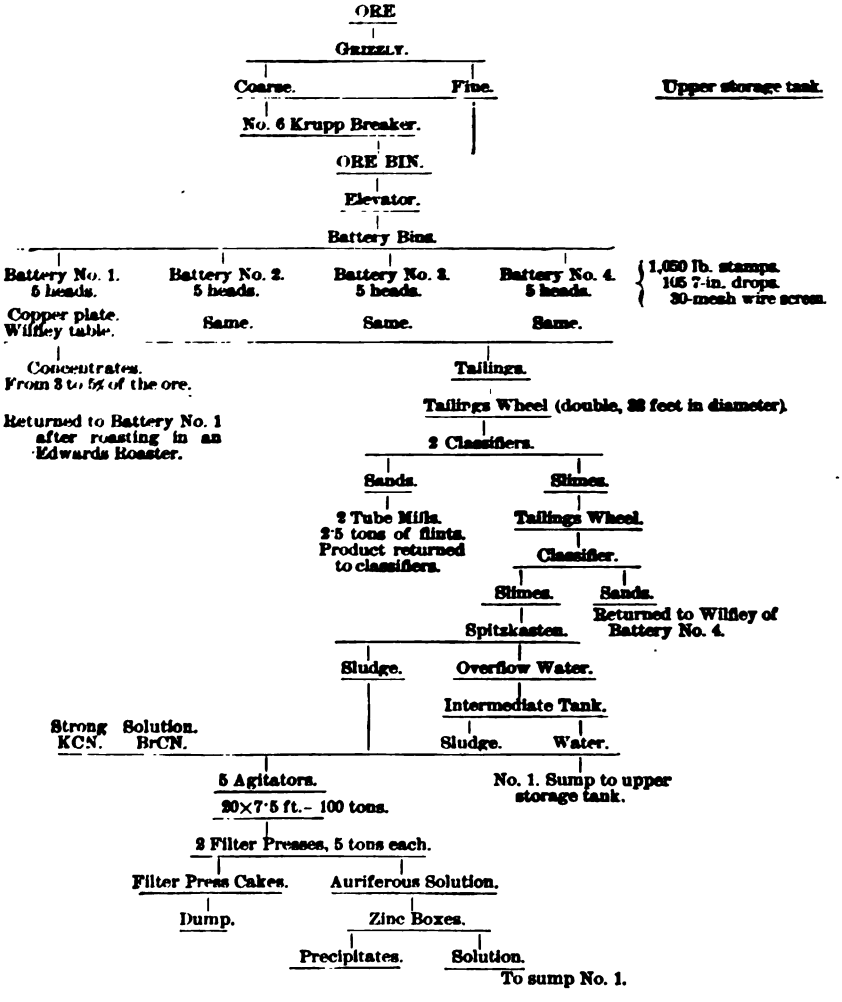
On 0·85-oz. ore the sands contained 26·24% of the gold value; the concentrates, 37·51%; the slimes, 35·37%; and amalgamable gold, 0·88%.

The best extraction on sands with a 7-day leaching did not exceed 50% of the gold. The best machine to slime the ore was found to be a Krupp tube mill.

[11] *Journal of the Chemical and Metallurgical Society of South Africa*, III., iv., 41, August, 1902.

[12] A paper read before the Institution of Mining and Metallurgy, June 19, 1902.

by the other, hence a comparison of costs is interesting. In August, 1901, the roasting process treated 3,411 tons of ore producing 5,287 oz. of bullion at a cost of $9·08 per ton. The Diehl process treated 5,888 tons producing 9,020·48 oz.



of bullion at a cost of $8·36 per ton. With the same kind of ore going to the plants, the extraction by the Diehl process was $28·16 per ton, as against $27·27 by the roasting process, the difference between these costs should be added to the cost of the roasting process.

At the Hannan's Star mill the ore is crushed dry in 2 No. 5 Krupp ball mills, through a 30-mesh screen, from which it goes to a mixing machine, where it is mixed with water. From here the pulp follows the same course as at the Hannan's Brownhill.

Refining of Precipitates.—Hamilton Wingate[13] describes the method used at the Waitekauri Extended mine, Maratoto, N. Z. Roasting the vacuum-dried

[13] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

placed on top of the slime charge to prevent loss by dusting and also to ha
an excess of litharge at the top of the charge. No absolute rule for fluxi
can be formulated as that depends upon the nature of the precipitates smelte
In practice it is found that considerably less slag (30% less) is required tha

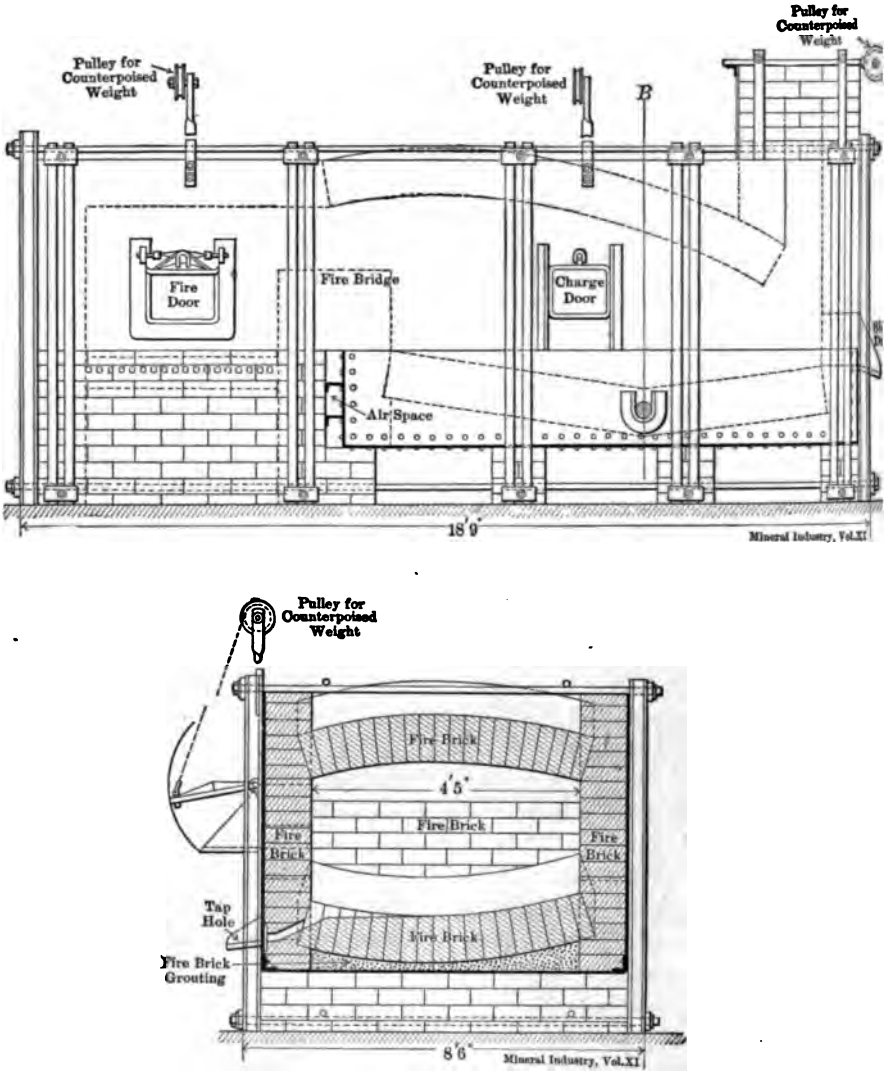
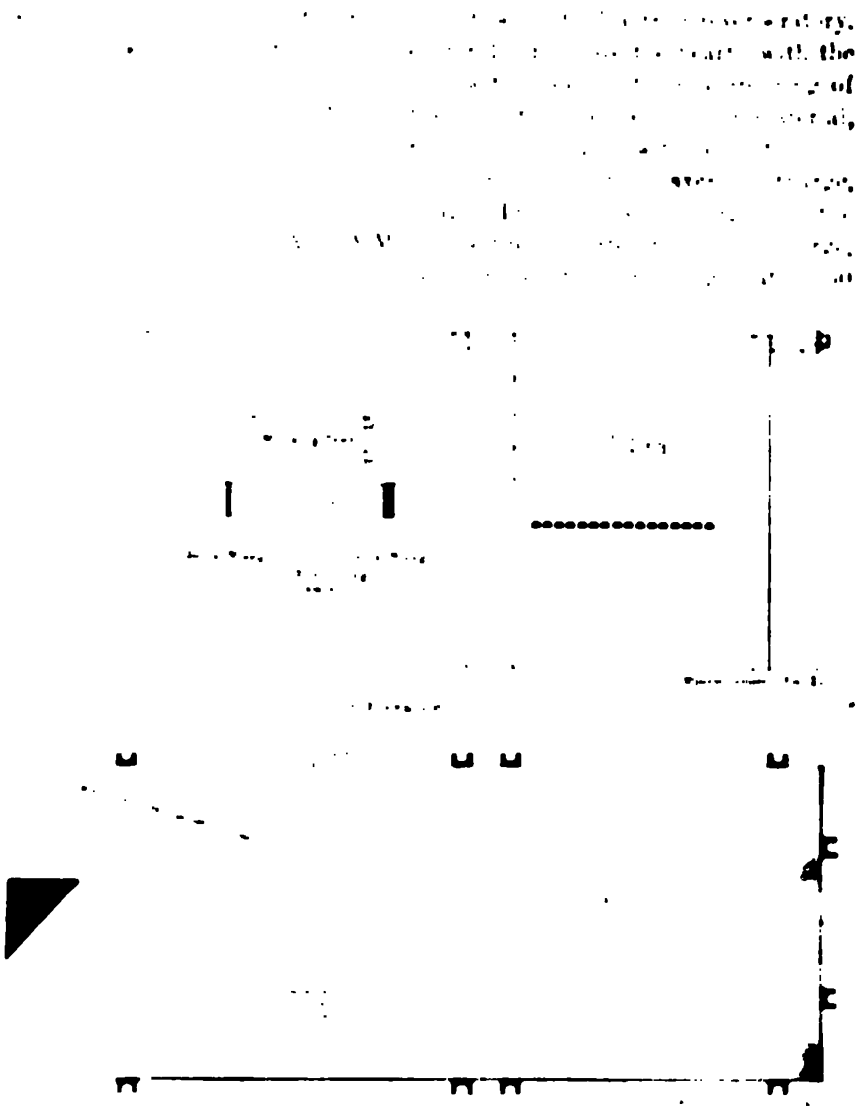


FIG. 1.—TAVENER'S FURNACE FOR SMELTING ZINC-GOLD SLIMES.

in smelting small quantities of precipitates in crucibles. The lead bullion p
duced should contain not more than 8% of gold—10% being the limit.
a reducing agent sawdust was employed to the amount of from 1 to 2% of t
weight of the litharge present. No sawdust is added with the fine zinc char
the zinc in the latter acting as the reducing agent. The reverberatory fur



bottoms being reserved for resmelting. The last of the slag is waved off by rabbling. The last skim of slag on the bath is thickened by cooling and throwing a shovelful of lime over the charge, when it is easily detached, and reserved for the next melt. A clean surface of lead is then exposed, and any zinc present quickly burns off. The lead recovered is clean and soft. The bullion is sampled accurately after stirring by taking a ladleful, and is then poured into bars.

The cupelling test is an oval, cast iron frame filled with bone ash ground to pass a 20-mesh sieve, and moistened with a potash solution of 1 lb. of potash for every 33 lb. of bone ash. The bone ash must be moistened just sufficiently so that if squeezed into a ball in the hand it will break clean. The test requires 500 lb. of bone ash to fill it, 300 lb. remaining after the necessary cutting out. (See Fig. 2.)

The test has a basin cut into it, from 2·5 to 3 in. deep, and is put away to dry at least two weeks before using. A cupel of this size is sufficient for four charges each of 1·5 tons of lead. The last one used at the Bonanza lasted 4 months, and cupelled 7·5 tons of lead bullion, producing 14,978 oz. of bullion.

When the new cupel is placed in the furnace a slow fire is kept burning for 3 or 4 hours before starting to refine. The blast is introduced into the test by a 3-in. pipe flattened at the end, and turned down so that the blast may strike the lead. The temperature is now raised to melt lead, and six bars are put into the furnace by the working door. When these are melted, the temperature is increased, and the remainder of the lead is introduced through the feed chute, the ends of the bars being allowed to melt off gradually. Lead is thus fed in until the bath almost reaches the level of the litharge channel, which has been cut in the meanwhile. The temperature is then increased to the melting point of litharge, and as soon as the bath is covered with litharge the blast is turned on, the litharge formed running into a pot similar to a slag pot, but only 12 in. in diameter and 8 in. deep. The flow of litharge is controlled by the quantity of lead melted from the bars introduced through the feed chute. When the feeding is completed, and there remains only the bath of concentrated bullion, the temperature is raised, and the litharge channel deepened. Nearly all the copper in the bullion enters the litharge just before the completion of the operation, which makes the litharge thick and heavy and requires a high temperature. Just before the cupellation is finished there is danger that the bath will freeze under the cold blast; if that occurs the blast is shut off and the temperature raised until the bath is molten again, after which the blast is turned on and the last impurity driven off. From 6 to 8 lb. of assay slag are then added and melted, and allowed to run off, and by this means the gold is given a clean, bright surface. The fire door is now opened and the gold allowed to cool to a point where it will not crumble when a bar is inserted under the cake. This is lifted, broken in halves, and pulled out into a slag pot. The gold is remelted in crucibles and cast into bars. The advantages of the process can be stated as follows: 1. Saving in cost of treatment. 2. Absence of by-products. 3. Reduced loss in handling. 4. Increased recovery of gold. 5. Facility for treating foul slag.

The results of four months' smelting at the Bonanza are as follows: Weight of moist filter press slimes, 9,058 lb.; of fine zinc, 7,662 lb.; lead bullion cupelled,

per ton. The concentrates are treated first with a plain water or alkaline wash, followed by a weak solution wash 0·10 to 0·12% cyanide, and then nine washes of 0·3% cyanide. The contents of the vat are then turned over, and are treated until for two successive days the effluent solution runs 0·26% cyanide, when the treatment is considered complete. Then follow two washes from the strong sump, 0·25% cyanide, and two weak washes, 0·07%, finally one or two wash waters. From 17 to 20 tons of concentrates are treated per month. The time of treatment is 24 days, and the extraction is 84%. The zinc boxes are made up at the commencement of the treatment and left untouched to the end, all solutions passing through the box as they come from the percolating vat. The precipitates that pass a 30-mesh screen carry nearly as much silver as gold, those that remain on a 30-mesh screen carry practically no silver, but much copper. All the zinc in the box becomes copper coated almost immediately on being put to use. The method of treating the precipitates is as follows: Careful cold acid treatment is followed by a thorough washing and drying in enameled basins, and fluxing the slimes below 30-mesh size with 27% borax, 18% sand, 13% soda, 10% niter. The slimes above 30-mesh size are fluxed with 45% borax, 27% sand, 22·5% soda and 16% niter. The slags run about 8 oz. gold per ton and contain no shot. The bullion from the fine slimes is from 560 to 600 fine, and from the coarse slimes from 500 to 540 fine. The detailed cost of treating 89 tons of concentrates was: Pumping, 13·5c.; supervision, 86c.; labor, 11c.; cyanide (5·12 lb.), $1·345; zinc (0·85 lb.), 7c.; reduction, assaying and sundries, 59c. Total, $3·12 per ton. The tailings assayed 0·25 oz. of gold per ton.

Herbert K. Scott,[17] in his paper on "The Gold Fields of Minas Geraes, Brazil," mentions the success obtained in treating concentrates by the cyanide process at various mines in the State of Minas Geraes, Brazil. At the Moro Velho mine, concentrates from strakes consisting of pyrrhotite, pyrite and mispickel are treated by an "oxygen process," which is a modified cyanide process embracing agitation and aëriation. The Passagem mine of the Ouro Preto Gold Mining Co. in the same district, after experimenting with the same class of material with a modified cyanide process with good results, will replace barrel chlorination of the concentrates by cyaniding. At the Faria mines, near Honoria Bicalho, on the Central Railway of Brazil, the pulp from the batteries passes over amalgamated plates, and into two spitzlütten, which separate out the heavy concentrates. The tailings overflow from the spitzlütten pass to two spitzkasten, which separate the sands from the slimes. The sands and the concentrates are treated separately by percolation, and the slimes by the filter press process. Johnson presses are being used. An extraction of 90% is obtained on the sands, and 55% on the slimes.

At the Sao Bento mines, near Santa Barbara, oxidized siliceous ores are crushed by Blake crushers and Gates rolls to pass a screen of 0·15-cm. opening. An extraction of 86·6% is obtained.

Commercial Potassium Cyanide.—According to A. Whitby[18] the difference in composition of the salt sold as "98% potassium cyanide," is considerable.

[17] *A paper read before the American Institute of Mining Engineers, May, 1902.*

[18] *A paper read before the Chemical and Metallurgical Society of South Africa, Dec. 20, 1902.*

According to R. W. Moore,[19] of 80 samples of commercial potassium cyanide imported into the United States, only 24 contained no sodium cyanide, while 50 contained from 10 to 54% of sodium cyanide, averaging 22%, it being evident that much of the cyanide used in the process is a mixture of sodium and potassium cyanide. Under the Dingley tariff, potassium cyanide is admitted under a duty of 12·5%, which is one-half that on chemical salts. The question came up for the Board of General Appraisers as to what duty is to be paid on a mixture of sodium and potassium cyanides, and the decision reached was that the mixture should be admitted as potassium cyanide.

Treatment of Cupriferous Gold Ores.—Louis Janin, Jr.,[20] discusses the treatment of cupriferous gold ores by the cyanide process. Three methods are advocated which have in view the entire or partial elimination of the copper and the consequent protection of the potassium cyanide. They are:—

1. Leaching by sulphuric acid preliminary to cyanide treatment.

2. Scrymgeour's method of dissolving copper minerals in a solution of potassium cuprocyanide, containing no free potassium cyanide.

3. Bertram Hunt's method of leaching with an ammoniacal cyanide solution.

While many copper minerals are soluble in sulphuric acid, this method has serious drawbacks in that it may have a very high consumption of acid if lime and magnesian carbonates are present in the ore. There is also a tendency for the ore to cement and pack in the tanks after the acid treatment. A neutralizing agent such as a caustic soda solution must follow the acid treatment, otherwise the consumption of cyanide will be more even than when treating the original ore before acid treatment. Burnt lime, as ordinarily employed, will not penetrate the ore mass to neutralize the acid. The acid process is then a three-stage process. 1. Leaching the ore with dilute sulphuric acid. 2. Neutralizing the acid remaining with caustic soda. 3. Treatment with cyanide solution.

Scrymgeour's method depends upon the property of potassium cuprocyanide to dissolve copper in certain minerals. The cuprocyanide is obtained by heating the ore with dilute cyanide solution. When the cuprocyanide solution has dissolved the maximum of copper in the form of sub-cyanide the excess of copper is precipitated electrolytically. Then the ore is ready for the ordinary treatment with dilute cyanide solution. The method is a two-stage one employing separate electrolytic precipitation vats, and separate storage tanks.[21]

Bertram Hunt's method is very simple, and essentially a one-stage process. It depends upon the protective influence of ammonia as well as its solvent action for copper, the ammonia and cyanide being employed in the same solution. It is known that the double salt of copper and potassium cyanide has a solvent action on gold. It is not so well known that the cyanides of gold, silver and copper, and other base metals are soluble in ammonia. When a solution of cupric oxide is dissolved in ammonia containing less cyanide than will combine with the copper, then an alkali cupricyanide is formed which exerts a solvent action on the gold equal to the cyanide itself.

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[19] *Journal of the Society of Chemical Industry*, Vol. 21, p. 892.

[20] *Engineering and Mining Journal*, p. 816, Dec. 20, 1902.

[21] *See also Engineering and Mining Journal*, Aug. 17, 1901, and THE MINERAL INDUSTRY, Vol. X., pp. 30 and 32.

cyanide, part of the cost in some cases may be made up by the value of the copper recovered.

5. Unlike the acid treatment, calcareous ores are amenable to the process.

6. There is no limitation to the copper content of the ores which can be treated economically under local conditions, though with high-grade copper ore a plant would have to be installed for ammonia recovery.

It presents a good field for oxidized copper-gold tailings or ores, and possibly may be extended to pyritic ores.

Important Patents Issued during the Year.—Several patents have been granted during the year, of which some may in time have an important bearing on the cyanide process.

A patent has been issued to Ed. D. Kendall, of Brooklyn, N. Y., for the electrolytic recovery of precious metals dissolved in cyanide solutions. The gold-bearing cyanide solution is filtered through a mass of hard fragmental carbon pocketed around the porous cup of an electrolytic cell, and connected as the cathode of a 15-volt current. A carbon plate as anode is placed in the porous cup and immersed in a solution of caustic alkali. The cyanogen set free collects in the caustic alkali solution of the anode, and the precious metals are deposited in a pulverulent form throughout the mass of the cathode. After the deposition of the gold, the two compartments are emptied of their solution, a silvered carbon plate rubbed with graphite replaces the former carbon anode plate, the current is reversed and a strong solution of potassium cyanide is permitted to flow through the cell, successively through the anode and cathode compartments in the order named. The gold is redissolved from the former cathode and deposited in reguline form on the silvered carbon plate now forming the cathode. The idea was first suggested by Dr. Pfleger in 1895, and further developed, and its advantage pointed out by Prof. S. B. Christy.

United States Patent No. 687,258, for the recovery of cyanide from waste and foul solutions, has been issued to William Orr, of Salt Lake City, Utah, and controlled by the Gold & Silver Extraction Co. of America. The quantity of potassium cyanide and potassium-zinc cyanide is determined in the waste solution; the waste solutions are then run into a suitable tank, and the proper quantity of fused zinc chloride added to precipitate all the cyanogen as zinc cyanide. The solution is then separated from the precipitate by decantation or filtering, after which a solution of alkali hydrate is added to dissolve the zinc cyanide. The correct quantity of potassium or sodium sulphide is then added to precipitate the zinc, which is separated, the solution then being again ready for use.

Miscellaneous.—According to Wm. J. Sharwood[22] selenium is found in the precipitates from the cyanide process and may come from the presence of the silver and copper selenides in the ores, both of which are slowly soluble in potassium cyanide, as potassium seleno-cyanide, KCNSe, from which zinc precipitates selenium. If, however, the selenium is found in the precipitate after treatment with sulphuric acid, the selenium probably came from the acid, being precipitated from it by the zinc.

[22] *Engineering and Mining Journal*, p. 688, Nov. 23, 1901.

Cyanide Patent Decisions.—In an action in Queensland, Australia, the chief justice of that State, upheld the validity of the MacArthur-Forrest cyanide patents. The patents have also been successfully maintained in New Zealand and Victoria. In West Australia and New South Wales the courts have held that there was either no novelty or that the specifications were too broad. In the United States, the matter has never been really brought to trial. In the suit against the Mercur Co., of Utah, the latter compromised by agreeing to pay a small royalty. In Mexico and other Spanish-American countries the patents hold good. In South Africa, under the Republic, the patents were declared invalid, but as the Transvaal is now a British colony under the patent laws of the mother country, the patent which is good in England will probably be declared good in the Transvaal, and will raise interesting questions of royalty to be paid. The patents have at most but a few years to live in the different countries, and it is questionable whether in view of the broad lines of the process renewals will be granted.

By a decision of the United States Circuit Court of Appeals, and held as final, zinc dust is admitted free according to paragraph 482, Act of 1897.

CYANIDING SULPHO-TELLURIDE ORES.

BY PHILIP ARGALL.

THE successful use of bromo-cyanide in the treatment of the unroasted sulpho-telluride ores of Western Australia has attracted quite a little attention in the United States, more particularly, perhaps, from those having mining interests in Cripple Creek, Colo. The very fact that sulpho-telluride ores can be treated without roasting, appeals at once to the small producer, who immediately sees a method for reducing his ore to bullion without the use of the usual cumbersome and often expensive roasting plant.

The method of working the Western Australian ores in the raw state, by means of fine grinding and subsequent treatment with bromo-cyanide, is known as the "Diehl" process (see preceding pages of this volume), apparently now established as an economic and commercial success in the treatment of Kalgoorlie ores. I herewith propose to compare this process of cyaniding with the roasting method as heretofore practiced on the ores of Cripple Creek.

The Kalgoorlie ores contain a large quantity of calcium and iron carbonates, together with a small quantity of magnesia. Estimating the latter component as $CaCO_3$, Mr. H. Knutsen gives the following approximate analysis of three samples: Insoluble, 57·98%, 59·61%, and 76·91%; $FeCO_3$, 19·29%, 13·94%, and 12·11%, and $CaCO_3$, 22·55%, 26·73%, and 9·18%.

The sulphur appears to have been neglected in the analysis. Mr. Alfred James, however, gives as a typical analysis of these ores: SiO_2 about 50%, Fe 10%, Al_2O_3 5 to 20% or more, MgO 1 to 5%, S 3 to 7%, Cu 0·1 to 0·3%, Pb trace, Zn 0·02%. As trace, Sb 0·02%, Te 0·03 to 0·1%, and $CaCO_3$ 6 to 17%. Ores of this character after roasting when the solutions reach them form a lime-iron cement which sets hard in the tanks and greatly interferes with, and often prevents, the percolation of the solutions through the charges. For this reason

(4) Sliming all the tailings from the concentrators so the material will pass a 200-mesh screen.

(5) Agitating this fine pulp for at least 24 hours in cyanide solutions, to which a solution of bromo-cyanogen is added from time to time.

(6) Filter pressing the agitated slimes.

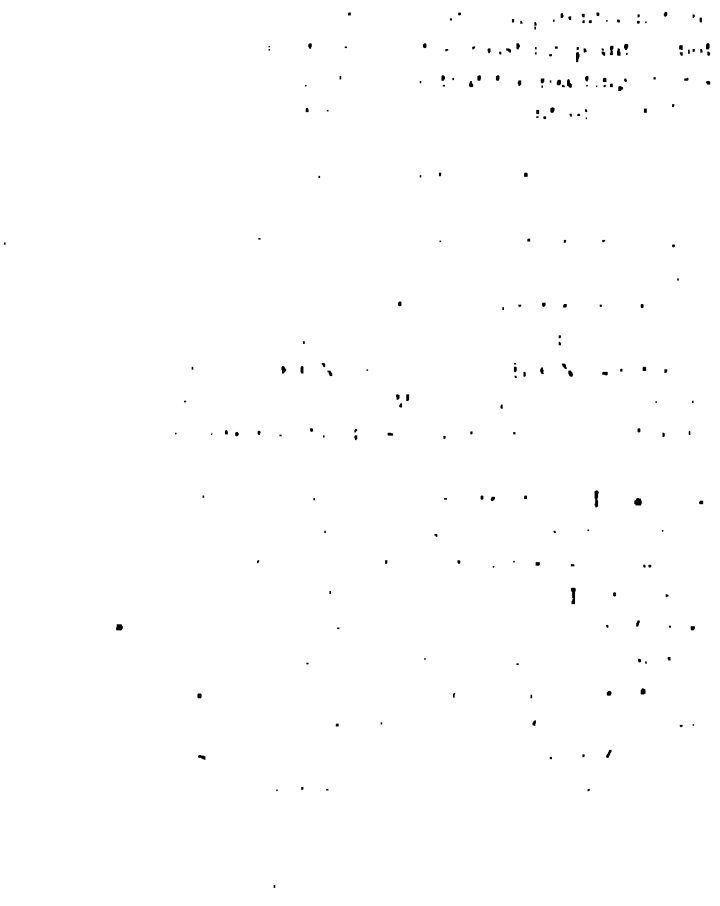
The Diehl process is fully described by Mr. H. Knutsen[1] in a very able and interesting paper from which the following comparative data of costs are taken. The process is in use at one property alongside a roasting plant, both treating the same class of ores; in the roasting plant two-thirds of the ore is treated in filter presses and one-third in leaching tanks, while in the Diehl all the ore must be filter pressed.

In the roasting process, 3,411 tons were treated, which yielded 5,287 oz. of bullion and no concentrates, while with the Diehl process 5,888 tons were treated, yielding 5,201 oz. of bullion and leaving 3,819·47 oz. in the concentrates. If the concentrates represent but 0·5% of the ore, as reported, then practically 42% of the value of the crude ore is locked up in about 30 tons of concentrates. These latter are treated at the smelting works. A summary of expenditure per ton of ore treated during August, 1901, is given in the subjoined table.

	Roasting Process.	Diehl Process.		Roasting Process.	Diehl Process.
	s. d.	s. d.		s. d.	s. d.
Superintendence	1 5·051	1 0·013	Elevating	... .	0 3·461
General stores and charges	1 4·306	1 7·486	Cyanogen bromide	... .	4 0·048
Electric light	1 4·561	1 2·514	Potassium cyanide	3 0·277	2 9·586
Assay, retorting and smelting	1 9·036	1 6·075	Zinc	3 2·418	2 2·327
Fuel	9 2·548	3 5·746	Filling and emptying presses	1 8·253	2 6·171
Water	3 5·046	3 2·347	Filter cloth	0 4·736	0 3·098
Compressed air	1 4·254	2 0·209	Chemicals	0 1·049	0 1·091
Filling and emptying vats	1 2·564	... .	Firing roaster	1 2·958	... .
Labor, general	1 1·978	1 10·618	Agitation	1 2·723	... .
Engine driving and firing	0 11·479	0 7·662	Royalty	... .	1 9·198
General repairs	3 3·058	2 3·224			
Screens, shoes and dies	... .	0 0·340	Totals	37 4·295	33 9·080

Taking the difference in fuel cost between the two processes, and adding the expense of firing the roaster, the approximate cost of roasting is found to be 6s. 11·7600d. The cost of bromo-cyanide is 4s. per ton of ore treated: to this, the royalty for the use of the process should be added, and a total of 5s. 9·24d. is obtained as an offset to the roasting, which shows 1s. 2·5d. in favor of the Diehl process. It was claimed that the same quality of ore went to both plants, but the Diehl gave a return amounting to 3s. 8d. per ton more than that from the roasting process. This comparison appears to me to be somewhat favorable to the Diehl process, if, indeed, a strict comparison of the costs of the rival processes was intended; for example, the capacity of the roasting plant appears to be about 60% of that of the Diehl, yet the cost for supervision, engine driving, etc., is about 50% greater for the smaller plant. It is in the final products of the plants, however, that the most unfair comparison creeps in; the roasting process produces all its yield in bullion, while the Diehl leaves about 42% of the bullion content of the ore in the form of high-grade concentrates, which can neither be *handled* nor roasted without loss of metal. There is also an additional smelting

[1] *Proceedings of the Institution of Mining and Metallurgy*, 1902, London; see, also, THE MINERAL INDUSTRY, Vols IX. and X.



cost of milling the ore, extracting the values, and marketing the bullion on a basis of treating 500 tons per day, worked out to $1·75 per ton of ore. The proposed new method of treatment not only substantially reduced the working cost, but gave also an increased extraction over that attained at the old plant.

On the strength of this discovery and on the improvements that could be made in a new plant, a site for the proposed works was selected near Cañon City, and the Florence & Cripple Creek Railroad extended a branch into that city to accommodate the plant; however, before the new road was completed both the Metallic Extraction Co.'s works and the railroads were under option for sale, and were subsequently sold, which caused the scheme for the cheap milling of Cripple Creek ores to fall through, and with it, for a time at least, the prospect of treating $5 ores at a profit to the miner.

It is true that those results have not been attained in practical working on a commercial scale, but, nevertheless, there is no question as to their accuracy or of the fact that Cripple Creek ores can be roasted and cyanided in a modern up-to-date plant of 500 tons daily capacity at a cost of $1·75 per ton. But one need not enter into the question of the total cost of cyaniding Cripple Creek ores in order to compare the Diehl with the roasting process now in use. I believe the following will suffice:—

Diehl Process.	Cost.	Roasting Process.	Cost.
Bromo-cyanogen and royalty	$1·00	Roasting	$0·50
Fine grinding	·50	Tank work	0·25
Filter press work and agitation	1·25	Total	$0·75
Total	$2·75	Difference in favor of the roasting process	$2·00

Assuming the cyanide consumption to be the same in each case, it is evident that the cost of bromo-cyanide, plus grinding from 30-mesh size to 200-mesh size, plus filter press work, plus concentration, would have to aggregate less than $1 per ton before the Diehl process could compete successfully with the roasting process in the treatment of Cripple Creek sulpho-telluride ores. Therefore, the latter process must prevail at Cripple Creek, as, in my opinion, it will ultimately prevail at Kalgoorlie.

The Treatment of Sulpho-Telluride Ores at Kalgoorlie.[1]

By W. A. Prichard and H. C. Hoover.

Introductory.—The Kalgoorlie field, the mines of which practically are limited to one square mile, has during the eight years since its discovery, to the end of 1902, produced gold to the value of £14,873,982. The feverish requirements of the London stock markets, into whose hands fell the development of these fabulous deposits of refractory ore, coupled with the universal inexperience in dealing with ores of this class, resulted in a number of serious blunders in metallurgical treatment.[2] There has been expended in metallurgical works on this square mile over $8,000,000, much of which has been devoted to the acquirement of experience. Some companies are now operating their second or third plants, and, on the other

[1] *Engineering and Mining Journal*, Aug. 1, 1903.

[2] Admirable detailed discussion of the practice on the Great Boulder Proprietary, by Mr. G. M. Roberts, appeared in the *Monthly Report* of the Kalgoorlie Chamber of Mines for July, and of the Diehl Process by De Knutzen in the *Proceedings of the Institution of Mining and Metallurgy* for 1903.

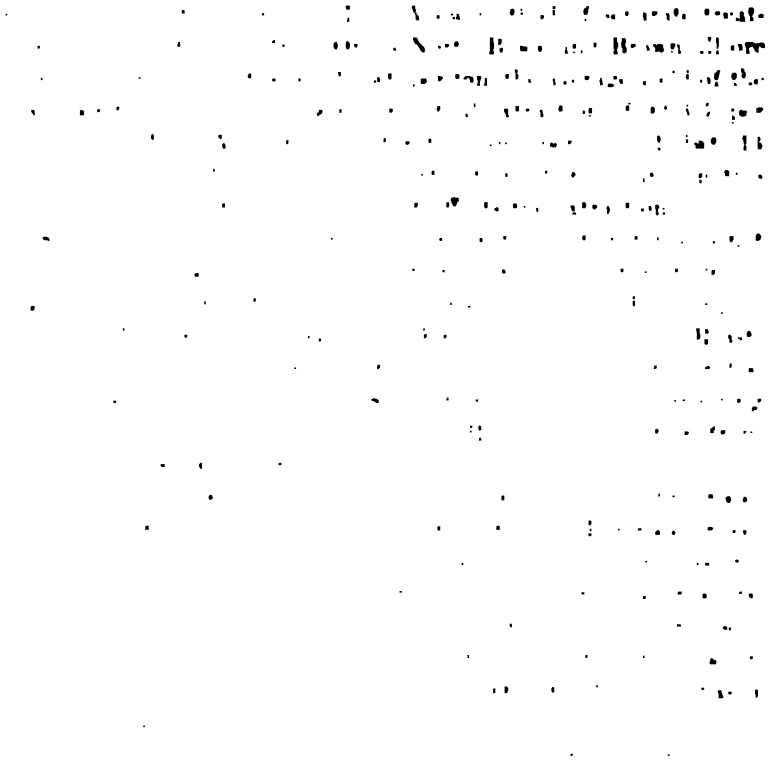
The other form of treatment, which usually goes by the name of the "Roasting Process," is in use on the Great Boulder Proprietary, Great Boulder Perseverance, Associated Gold mines, Kalgurli, South Kalgurli, and Great Boulder Main Reef. The Ivanhoe mine, whose output ranks fourth on the field, is not yet completely equipped for treating the whole of its ore, nor for securing the most efficient extraction. The working cost is the lowest on the field, but the work is incomplete. The Golden Horseshoe mine, whose output ranks second, is in the same position but with the highest cost. The line of development on both these mines is, however, toward wet crushing by stamps, amalgamation of free gold, concentration and incomplete treatment of tailings being secured by ordinary cyanide and filter press treatment. In both these mines, the richest telluride ores are either mined separately or sorted, and then treated either by smelting or in a small roasting plant. Neither mine has yet solved the problem, *i.e.*, efficient extraction.

Dichl Process.—The essential metallurgical features of this process in its best development are given on pp. 335 and 336 of this volume.

In the Lake View mill, stamps of 1,100 lb. are used, and, as prior to concentration coarse crushing is advantageous, an average duty of 5 tons (of 2,240 lb.) is obtained. Of the product 38% (slimes) will pass 150-mesh screen. If the fineness be increased to 55% slime, the duty is lowered to 3·5 tons, but sliming is secured more economically in the tube mills and, therefore, furnishes a second reason why the high mill duty is desirable. After concentration, the sands are separated in spitzkasten, and run into the tube mills filled with flint cobbles. From these mills, all tailings which will pass the outlet spitzkasten join the slimes from the entrance spitzkasten, and the sands return again to the tube mill. The slimes pass to closed agitators, where bromo-cyanogen is introduced, the period of agitation being about 24 hours. The slimes are then introduced either by pumps or montejus to the filter presses, for recovery of solutions, and the gold precipitated therefrom in the usual way.

The concentrates are amalgamated and then roasted in Edwards or Merton furnaces, the residues being treated by plain cyanide. For roasting concentrates but little fuel is needed, the sulphides furnishing much of the required heat. It has been found in treating concentrates that a much larger tonnage can be roasted when a considerable portion of coarse sand is included with the concentrates. The inclusion of coarse sand with the concentrates has the advantage of throwing more gold, sulphides and tellurides into the concentrates, thereby decreasing the consumption of cyanide and bromo-cyanogen in the slimes treatment. A close concentration, though unnecessary, is very desirable in the bromo-cyanogen process, and it is found, as stated above, that in practice the amount of cyanide and bromo-cyanide required to recover the gold from the tailings increases with the amount of concentrates remaining in them when the slimes are treated. The difficulty is both mechanical and chemical. There is still a further advantage where royalty is paid on gold recovered by bromo-cyanogen, the cost for royalty is reduced by throwing more gold into concentrates. At the Lake View Consols over 50% of gold is obtained from the concentrates.

In the case of the Oroya Brownhill, the concentrates were returned to the *battery after* roasting, being amalgamated prior to concentration, and consider-



the same grade shows a difference of from 1 to 3%, generally in favor of the Diehl method. However, much depends upon the efficiency of the individual plant. In initial expenditure, the advantage lies on the side of the Diehl process, largely owing to the more limited outlay on roasting and appliances and less cost of erection. In working expenditure the advantages on the side of the Diehl process are: (1) Preliminary breaking in one stage. (2) Cheaper crushing wet. (3) By concentration the product necessary to roast is less than 5% of the total ore against 100% in the roasting process. (4) Less cost of maintenance and wear and tear. The advantages of the roasting process are: (1) Less cost in chemicals. (2) No royalties. The other operations fairly well compensate each other, and it seems that the Diehl process should have, under equally efficient management, about 2s. 6d. or 60c. per ton the advantage in costs.

Working Costs.—Working costs are difficult of comparison even on so limited a field as Kalgoorlie. The factors bearing on comparative costs are not wholly the efficiency of management or the process in use. In the first instance, there is a great difference of volume in ore treated at different plants, and consequently an increased cost per ton in smaller mills from fixed charges, and decreased cost in larger mills by the range of supervision of each employé. Moreover, the hardness of the ore varies greatly, not only in different mines, but in the same mine; in general, it increases toward the southern end of the field. The consumption of chemicals varies with the richness of the ore. Besides these factors, the cost of water varies considerably; some mines obtain a portion from their own property, others are compelled to purchase all that they use.

The Oroya Brownhill and Lake View Consols mines, using the Diehl process, represent two extremes of conditions. Oroya Brownhill treats an average of about 4,000 tons per month of ore averaging over 2 oz. per ton, being one of the smaller mines as regard tonnage, and the richest in character of ore treated. The Lake View treats about 7,500 tons per month of an average value of about 14 dwt., this being the lowest grade sulphide ore treated. The costs include all charges except general management.

	Oroya Brownhill.	Lake View Consols.
	Shillings.	Shillings.
Milling	3·38	3·61
Concentrating	1·81	2·17
Treatment of concentrates	15·81	10·45
Total	21·00	16·23

For the month of May the Oroya Brownhill costs were further reduced by 1s. 6d. or 36c. per ton, to 19s. 6d. or $4·68.

Of mines using the roasting process, the working costs of the Great Boulder Proprietary, treating about 9,400 tons per month, and the Great Boulder Perseverance, treating between 11,000 and 12,000 tons per month, not including general management, but including superintendence of the plant, as given in their annual report for 1902, are 23s., or $5·52, for the former, and 22s., or $5·50, for the latter. Some reductions have been effected since that date, and the costs of the latter mine are given at 19s. 6d. or $4·68 for May.

GRAPHITE.

In the trade the mineral graphite is classified into "crystalline" and "amo phous," the former constituting the finer grades used chiefly for the manu facture of fire-resisting products, in lubrication, in electrotyping, etc., whi the latter is of inferior quality and suited only for foundry facings, paint, sto polish, and similar purposes. Some of the amorphous product, however, esp cially that from Bavaria and Mexico, is utilized also in the manufacture pencils and in electrotyping work. The bulk of the supply of the best grad of crystalline graphite continues to be derived from Ceylon, which furnish at present about 80% of the total consumption of the United States. Th graphite is imported direct by steamer in packages of 600 lb. net weight eac The ore is sorted and graded into four products, which in the order of val are: Lump, chip, dust and sweepings. The lump and the chip varieties are us chiefly in the manufacture of graphite crucibles and lubricants, as well as f electrical purposes, while the dust and the sweepings are utilized mainly in t manufacture of foundry facings, stove polish and greases. The consumptio of crystalline graphite in the arts and manufactures is approximately as follow Crucibles, 55%; stove polish, 15%; foundry facings, 10%; paint, 5%; all other 10%. The last-named division includes powder, glazing, electrotyping, stea packing, pencils, and various minor uses. In spite of the development of t manufacture of artificial graphite by the electric furnace, the need for the natur graphite has increased very largely in recent years, due to the growth of the iro and steel industries, the largely increased use of copper and its alloys, the develo ment of electrical machinery, which calls for graphitized products, and t increased need for special lubricants. During 1902 the United States suppli from domestic ores but little more than one-tenth of the total consumption natural graphite for the year.

(Much of the information in the following technical review of the progress the graphite industry in the United States during 1902 has been contributed Mr. William F. Downs.) Interest in the search for good graphite propert continues, and although no new fields have been reported, much exploration wo has been done, and the producing mines have been more carefully examined f available ore. The continued high price of graphite and the increased demand f "American flake" are the principal reasons for the recent activity. For ma years a prejudice existed against American flake graphite, which was only moved in the late nineties by the enforced use of all grades of graphite resulti from the scarcity and very high price of the well-known grades. Manufactur finally came to the conclusion that the value of graphite for any purpose depend upon purity and physical condition, and not upon the geographical location of t deposits. A foreign demand exists for American flake graphite, although present the domestic consumption is so great as to exclude exports. The marl for graphite from low-grade disseminated flake ores has caused the question concentration to be more carefully studied than ever before. Operative pla have changed or improved their methods, and new processes are to be int duced in plants under construction. Two new features in concentration worthy of special notice: one, the use of petroleum vapor which is rapidly absorl by graphite and permits the flakes to be more readily separated by flotation fr

Dealers.—Standard Graphite Co., New York, N. Y.; Pettinos & Bros., South Bethlehem, Pa.

REVIEW OF PROGRESS IN THE GRAPHITE INDUSTRY DURING 1902.

Alabama.—The Allen Graphite Co., at Stockdale, Clay County, increased its output of flake graphite during 1902, and two new companies have been formed to develop graphite properties in other parts of the State. A deposit of graphite is reported near Taylorsville, Alexander County.

Massachusetts.—The graphite mines of the Massachusetts Graphite Co., near Sturbridge, Worcester County, has been in course of development during the year, a few small shipments of the crystalline product being made to consumers to test the quality of the product.

Montana.—The Crystal Graphite Co. has been developing its graphite deposit near Dillon, Beaverhead County. Two small adits were started on the outcrop, but at a short distance the vein became almost perpendicular in dip and the work on them ceased. Later, an adit was started on the side of the mountain to intercept the vein at a depth of 65 ft., and at the close of the year it had been extended a distance of 135 ft., which is calculated to be within a few feet of the deposit. Shipments of the product have been made to crucible manufacturers to test its quality. Work will be resumed early in 1903, and if the deposit proves of sufficient value a mill will be erected near the mine.

New Mexico.—Exploratory work was done during 1902 at the graphite properties, eight miles southwest of Raton, Colfax County, which are now under the control of the Standard Graphite Co., of New York, and an output of 65 short tons of high-grade amorphous graphite was shipped to Moosic, Lackawanna County, Pa., for manufacture into paint and foundry material. A 60-ft. adit was driven on the vein of graphite and 15 pit shafts and facings exposed the deposit at various points. The district about Raton is underlain with bituminous coal, the seams of which vary in thickness from 3 to 7 ft. In the portion where the graphite is found, a layer of lava in the form of a laccolite has intruded itself above the coal seam, and by its heat has metamorphosed the coal to graphite which assumed a columnar form. The graphite is of the amorphous variety, and contains a portion of the silica which was originally associated with the coal. The vein of graphite approximates a horizontal position, and varies in width from 3 in. to 2 ft. In many places the graphite is free from rock, but containing an intimate mixture of silica. Generally the graphite occurs in a clear clean vein although a part of it is often mixed with rock. The graphite vein is cut through by canyons, and can be traced for a considerable distance on opposite sides of a large mesa. In one canyon three tunnels varying in length from 10 to 60 ft. have been driven on the vein, each showing the occurrence of the graphite to be continuous.

New York.—There are numerous limestone deposits in Essex and neighboring counties which carry graphite distributed through the mass, or in small lenses of very rich ore. While a large number of these deposits have been and are being developed and promoted, the only ones of promise are those operated by the Joseph Dixon Crucible Co., which is running an adit to tap

[illegible] on the old mine on the Lead Hill, back of Tuscaloosa, and a [illegible] worked by the Columbia Graphite Co., on Warner Hill, between [illegible] and Green Point. At the close of the year, development work [illegible] far enough to prove the value of either of these deposits [illegible] Graphite Co. continues to operate its mines and mills at [illegible] at Hagan, on Lake George, although the latter plant was closed [illegible] end of the year for the purpose of prospecting the deposit. In [illegible] graphite which has been worked continuously since 1897, the [illegible] seems to have been a line of weakness during the geological uplift avail- [illegible] was made near the surface are very much pulverized, so that [illegible] a good percentage of graphite, the production is small, simply [illegible] the largeness of the flake. It is probable that when the workings [illegible] deeper, the graphite will be found in coarse flakes in the unaltered [illegible] No faulting has occurred along the vein throughout its course [illegible] prospect developed by the Gray Brothers, between Tuscaloosa and [illegible] belongs to the Tuscaloosa Graphite Co., which was organized for the purpose of working this deposit. A well designed 10-stamp mill has been [illegible] and mining began late in the year. While the production has been [illegible] above the paper figures, the company seems to have a good chance for success because the flake is coarse and the deposit is wider than any yet [illegible] the State. A much larger plant with systematical mining should handle [illegible] profitably.

[illegible] mining has been done at Potters Ile, in Warren County. A [illegible] has been sunk to a depth of 100 feet, and the vein is reported to be [illegible] from 4 to 6 feet wide in the drift near the bottom.

[illegible]

[illegible]

[illegible]

with hydrochloric acid. The material as it comes from the concentrator is added to an acid bath, agitated for four hours with live steam, and allowed to remain in the acid for 25 hours additional. It is then thoroughly washed to remove all traces of acid and dried, which yields a flake product stated to be equal in quality to the Ceylon chip graphite. The Pennsylvania Graphite Co., formerly operative in Berks County, has made no production since 1899.

Rhode Island.—The Rhode Island Graphite Co. has continued to operate the amorphous graphite mine near Providence. The graphite occurs mostly in the nature of pockets, although it is also found in two or three fissure veins. During the latter part of 1902 the grade of the product reached as high as from 65 to 70% C. It is of interest to note that in connection with the development of the graphite deposit, a vein of semi-anthracite coal has been opened up.

Washington.—The graphite deposits in this State, owned by the Shelbyville Consolidated Mining Co., have been abandoned, as the material could not be mined with profit.

Wisconsin.—The Wisconsin Graphite Co. is installing a complete modern mining plant at Steven's Point, and has added four large re-grinding machines at its works in Pittsburg, Pa. The product is amorphous graphite reported to assay in some specimens as high as 74% C. It is manufactured into paints, lubricants and paste.

Wyoming.—The principal graphite deposits are located at Hallock Canyon, near Laramie, Albany County, and are now operated by the Copper Cliff Mining Co.

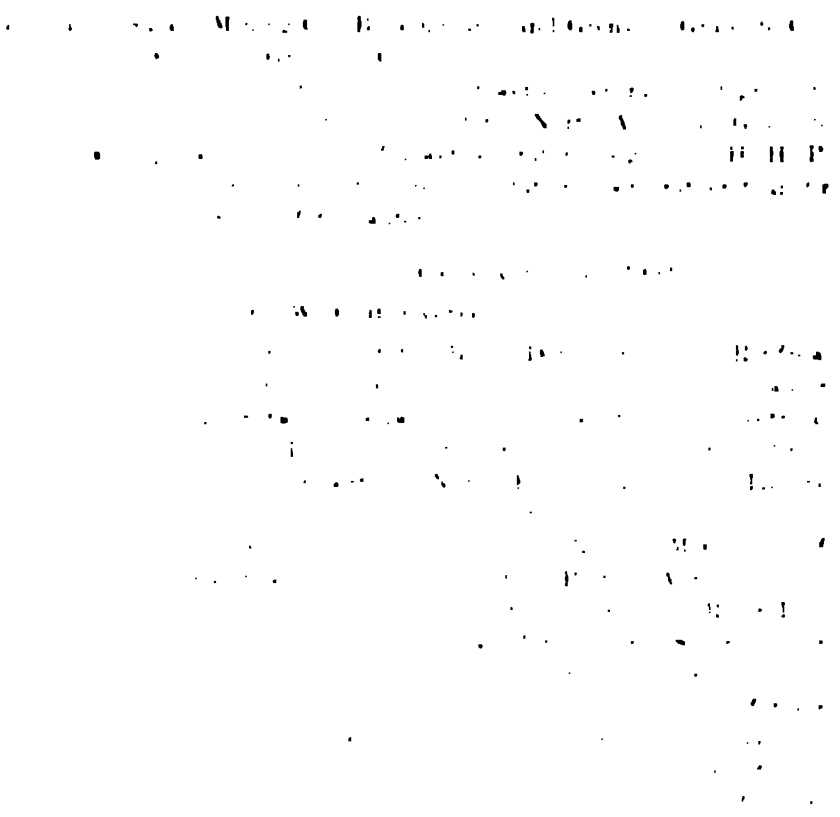
WORLD'S PRODUCTION OF GRAPHITE. (IN METRIC TONS.)

Year.	Austria	Canada	Ceylon. (d)	Germany.	India.	Italy.	Japan.	Mexico	Russia.	Spain.	Sweden	United States. (b)	Totals.
1897	38,504	396	19,275	3,861	61	5,650	204	907	(a)	(a)	99	450	69,811
1898	33,062	1,107	78,509	4,593	22	6,435	346	1,857	98	10	50	834	125,006
1899	31,819	1,105	29,087	5,196	1,548	9,990	55	2,305	29	(a)	(e) 515	1,648	80,962
1900	33,063	1,743	19,168	9,248	1,858	9,720	94	2,561	(c)	(a)	84	1,799	79,588
1901	29,902	2,005	22,707	4,435	2,580	10,313	(c)	762	(c)	(a)	(f) 56	1,834	74,694

(a) Not reported in the government statistics. (b) Crystalline graphite. (c) Statistics not yet published. (d) The figures for 1897, 1899 and 1900 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports for that year, which amounted to 24,349 metric tons. (e) Of this quanity 500 tons were crude product. (f) The production of crude graphite during 1901 was 1,725 metric tons, valued at $1,034.

Australia.—During 1901, 350 long tons of graphite were mined at Undercliff, in Wilson's Downfall Division, New South Wales. The deposit averages 2 ft. in width. Efforts have been made to develop a second graphite property in the same district.

Canada.—The production of graphite in Canada during 1902 was 1,095 short tons, valued at $28,300, as compared with 2,210 short tons, valued at $38,780 in 1901—in both years the output was derived mainly from the Black Donald mine, at Brougham, Renfrew County, Ont. The following companies are interested in graphite mining, although not all were numbered among the producers during 1902: *New Brunswick*—Canada Paint Co., near St. John Station. *Ontario*—Ontario Graphite Co.; Brougham & Globe Refining Co., Port Emsley. *Quebec*—*Calumet* Mining & Milling Graphite Co., Calumet; North American Graphite



as the more solid country rock is reached, and when the rock contains less than 15% C it is not mined, as at the present time this percentage is considered to be the minimum quantity for profitable treatment in the refinery.

Owing to the similarity in the specific gravity and the size between the flake and chlorite, the particles of the latter in the gangue cannot be separated entirely from the graphite in the process of concentration, and they contaminate the flake graphite product to such an extent as to reduce seriously its value for the manufacture of crucibles, for which it is chiefly used. In consequence, those portions of the deposit carrying chlorite are sorted out, together with the richer portions of the amorphous graphite, to form a product containing not less than 50% C that is shipped in the lump form for foundry facing purposes. The intermixed gangue is not seriously detrimental to this use.

The refinery, which has a capacity of 15 tons of ore per day, uses a wet process of concentration with large buddles. All of the material but the tails is dried either in an electric-heated or ordinary fire-heated revolving cylinder, sized, and then ground between millstones, which pulverize the gangue and amorphous graphite and merely polish the flake. After grinding, the product is passed through a series of revolving screens of gradually decreasing mesh, by which four sizes of flake are separated out, then a mixed flake and amorphous grade, and finally four or more sizes of amorphous graphite. The first flake is the coarsest and cleanest product, running about 10-mesh size and 96% C; the remaining grades of flake decrease in size, but all are over 90% pure. The amorphous grades are in powder form and carry from 54 to 62% C. The limestone remaining with the graphite after buddling pulverizes more readily than the graphite, and in the screening separates out from the graphite as dust.

This mine is exceptional, both as regards uniformity and quality of the graphite and size of the deposit. Since the erection of the refinery practically all the ore may be converted into valuable products, chief of which are the grades of flake for use in the manufacture of crucibles.

At the McConnell mine, operated by the Globe Refining Co., the graphite occurs along several mineralized zones or veins traversing the crystalline limestone. These zones occur along parallel or intersecting lines, and are somewhat lenticular in character. They lie nearly vertical, are from 8 to 30 ft. wide, and have been traced along the strike for more than several hundred feet. The graphite is entirely in flake form disseminated through the limestone, but the average carbon content is much less than that of the Black Donald mine. The refinery process also differs, including some new features of treatment which seem likely to prove successful. After coarse crushing and drying the ore is reduced to a fine size and screened several times to remove a considerable proportion of the limestone gangue as dust. A cleaner separation of the intermixed rock is effected by concentrating in pneumatic jigs, and the concentrates are then ground in a series of millstones. The polished and enriched flake discharged from the last stone undergoes wet buddling in small vats, which finish the work of concentration, after which the graphite is again dried, preparatory to the final grading in revolving screens into two or, when desired, more sizes, the coarsest being from *15 to 20-mesh* size. On account of the low content of carbon in the crude ore,

[illegible] adopted in order that the saving [illegible] of high grade suitable for [illegible] mineral reserves is from 15 to 20 tons of [illegible]

[illegible] situated in the township of Ham[illegible] [illegible] Am. of Hamilton, Ont. [illegible] Hamilton, where it is used [illegible] the property on a more extensive [illegible]

[illegible]

[illegible] [illegible] [illegible] [

of the necessary purity for work of this kind are so expensive that in most cases the price is prohibitive. Within the last year artificial graphite has been used successfully as a lubricant for high-grade work, and experiments have been made with artificial graphite for coating the grains of high explosives, the spontaneous ignition of which is supposed to result from a static charge of electricity on the grains, causing a spark which detonates the powder. By coating the grains with graphite the formation of the static charge is prevented.

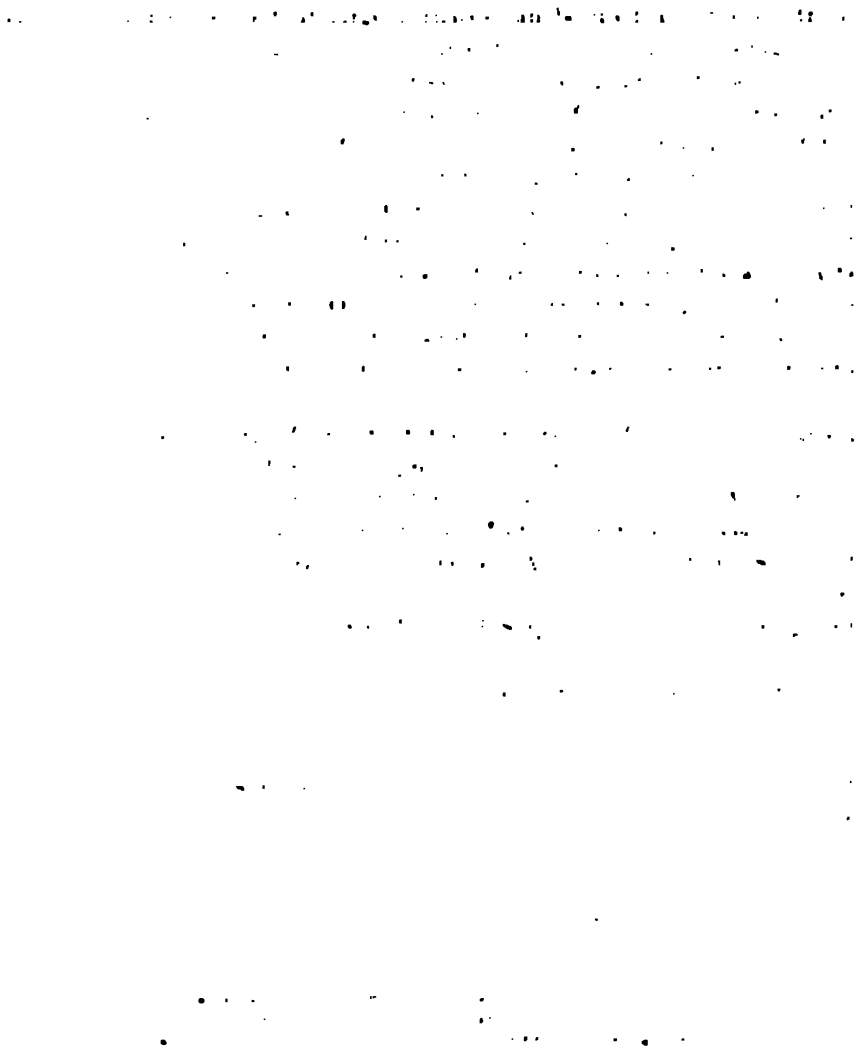
The production of graphite electrodes, as stated by F. A. J. Fitzgerald,[1] was not as large in 1902 as in the previous year, due to the fact that there were fewer new electrochemical works equipped. Graphitized electrodes have certain valuable properties which cause them to be used in preference to electrodes of amorphous carbon, these properties being the resistance of the electrode to oxidization when heated in the air, high electrical conductivity, and the ease with which they can be machined. According to H. Moissan, amorphous carbon is consumed when heated in oxygen at from 370° to 385° C., whereas it requires a temperature of 660°C. to burn artificial graphite. On account of the higher electrical conductivity of the artificial product, the cross section of the electrodes need only be one-third to one-fourth that required when the amorphous carbon variety is used, thereby exposing less surface to be oxidized. By the use of a screw thread to attach the electrode to the conducting wire a better contact can be made and new pieces can be attached from time to time to a partially consumed electrode, or the residual parts of old electrodes connected and used as a new electrode, so that none of the electrode is wasted. Slabs of material can also be dovetailed together to form partitions or boxes. The specific resistance of the artificial material is 0·00032 ohms per cu. in., or about one-fourth that of amorphous carbon. The following table[2] shows the results of experiments made with amorphous carbon and graphite electrodes in actual electrometallurgical work:—

Sieves.	Number, Size and Kind of Electrodes Used in Each Terminal.	Total Current in Amperes.	Current Density Amperes per Square Inch.	Average Hours Run.	Average Length Consumed.	Number of Runs.	Relative Weights Consumed per Hour.
A.....	Four—4 in. x 4 in. x 24 in. Amorphous carbons.	4,000	62·5	8	12 in. to 14 in.	4	1·000
B.....	Four—4 in. x 4 in. x 24 in. Acheson graphite.	4,000	62·5	33	12 in. to 14 in.	4	0·250
C.....	Four—2 in. x 4 in. x 24 in. Acheson graphite.	4,000	125·0	32	12 in. to 14 in.	15	0·125
D.....	Four—2 in. x 4 in. x 30 in. Acheson graphite.	4,000	125·0	95	22 in. to 24 in.	15	0·074

The electrodes in all cases were ranged side by side touching each other.

E. G. Acheson has patented[3] a new method of graphitizing electrodes, by subjecting them to the high temperature of an electric furnace. The electrodes are placed in piles separated from one another by spaces filled with a "material having a lower coefficient of electrical conductivity" than the electrodes. The current is then passed through the mass with the result that most of the heat energy is developed in the material in the spaces between the electrodes. The

[1] *Engineering and Mining Journal*, March 28, 1903, 484.
[2] C. L. Collins, *Transactions of the American Electrochemical Society*, I., No. 1, p. 53, 1902.
[3] United States Patent No. 701,758, June 17, 1902.



GYPSUM.

THE production of gypsum in the United States continued to increase greatly during 1902, although statistics of production during this year are not now available. The production during 1901 was 659,659 short tons, valued at $1,577,493.

PRODUCTION OF GYPSUM IN THE UNITED STATES. (*a*) (IN TONS OF 2,000 LB.)

States.	1900.	1901.	States.	1900.	1901.
California	*e* 3,500	3,550	Oregon	450	(*d*)
Colorado	4,000	*b* 17,394	South Dakota	750	(*d*)
Ind. Ter. and Oklahoma	16,975	(*d*)	Texas	42,000	(*f*)
Iowa	92,201	*c* 213,419	Utah	2,247	(*d*)
Kansas	*e* 90,000		Virginia	10,895	15,395
Michigan	150,000	185,150	Wyoming	2,995	(*g*)
Montana	325	(*d*)	Other States		105,305
New York	42,874	119,565			
Ohio	25,000	(*d*)	Total	484,202	659,659

(*a*) Statistics reporting the amount quarried. (*b*) Includes Wyoming. (*c*) Includes Texas. (*d*) Included in Other States. (*e*) Estimated. (*f*) Included with Iowa and Kansas. (*g*) Included with Colorado.

GYPSUM IMPORTED INTO THE UNITED STATES. (IN METRIC TONS.)

Year.	Ground or Calcined.			Unground.			Value of Manufactured Plaster of Paris.	Total.
	Quantity.	Value.	Per Metric Ton.	Quantity.	Value.	Per Metric Ton.		
1898	3,021	$18,500	$6·12	168,723	$181,364	$1·09	$40,979	$240,843
1899	3,317	19,250	5·80	199,724	220,608	1·10	58,078	297,936
1900	3,159	19,179	6·07	213,239	229,878	1·08	66,473	315,530
1901	3,156	19,627	6·22	238,971	238,440	0·99	68,603	326,670
1902	3,706	23,225	6·27	277,027	284,942	1·03	52,533	360,700

PRODUCTION OF GYPSUM IN THE PRINCIPAL COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Algeria. (*b*)	Canada.	France. (*b*)	Germany. (*c*)		Greece.	India.	United Kingdom	United States.
				Baden.	Bavaria.				
1897	36,750	217,392	2,004,339	40,702	26,153	51	8,187	184,287	272,498
1898	37,337	198,908	2,115,261	28,037	25,688	88	8,390	199,174	265,644
1899	39,950	221,802	1,807,454	29,119	29,727	81	6,546	215,974	342,891
1900	46,875	228,713	1,950,222	26,391	35,484	129	4,415	211,436	439,225
1901	44,025	276,605	2,385,633	28,183	3,581	671	(*d*)	204,045	598,589
1902	(*d*)	301,329	(*d*)	(*d*)	31,701	*Nil.*	(*d*)	172,219	.....

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) A part of the product is reported as plaster of Paris. In converting this to crude gypsum it has been assumed that the loss by calcination is 20%. (*c*) Prussia is a large producer of gypsum, but there are no complete statistics available. (*d*) Statistics not yet available.

Deposits of gypsum have been found near Sunset, Kern County, Cal., but have not yet been developed. A Tacoma gypsum company has bought a gypsum deposit on Freshwater Bay, Wash., and will erect a refining plant at Tacoma which is to have a yearly output of 15,000 to 20,000 tons of plaster of Paris and fertilizer. The gypsum deposit is said to be 70 ft. wide and 1,000 ft. long, and a tramway 3,500 ft. long is being built to convey the mineral from the quarries to the barges which will transport it to Tacoma.

Kansas, Oklahoma, Indian Territory, Texas, and the one at Laramie, Wyo., use the gypsum earth. This variety of gypsum produces a dark colored plaster, due to impurities, commonly spoken of as the "brown coat." It is employed to put on what corresponds to the first two coats of the old-fashioned lime mortar, and must be followed by a white coating of plaster made from rock gypsum, or from white lime.

The gypsum business was quite healthy during 1902, large sales were made, and fair prices were realized.

Canada.—In 1901 there was only one factory in operation in Ontario, that of the Alabastine Co. of Paris, Ltd., which manufactured calcined plaster, cement wall plaster and alabastine from gypsum mined near Caledonia. A factory for making "wood fiber," a mixture of gypsum, sand and wood fiber, has been established at Toronto. Most of the gypsum mined in Canada is shipped to New York to be milled.

France.—The greater portion of the gypsum used for agricultural purposes was produced by the Department of Seine-et-Oise, the rest being divided among 24 departments. Plaster from gypsum was made in 36 departments, about 70%, however, was produced in the departments of Seine-et-Oise, Seine, and Seine-et-Marne, the greatest deposits being at Montmaitre.

According to F. A. Wilder[1] the following cements containing gypsum are unusually hard, uniform in structure, set slowly and permit the addition of coloring matter without loss of strength. In hardness, they stand half way between Portland cement and stucco. Keene's cement is a slow setting alum plaster manufactured from unground gypsum, preferably of a white variety, which is burned at a red heat, then immersed in an alum solution, burned again at a red heat and then finely ground. If mixed with 20% water, it has a tensile strength of 70 lb. and a crushing strength of 800 lb. per sq. cm. Parian cement consists of 44 parts calcined gypsum and 1 part calcined borax. The gypsum is saturated with a borax solution and burned at a red heat. It sets slowly and dries in 5 or 6 hours. Scagliola is a mixture of finely burned plaster and lime-water, which is made into slabs for wall decorations. Gypsum heated to 1,000°F. and then coarsely ground is called estrick gypsum. This material when allowed to settle slowly, protected from draft and heat, becomes exceedingly hard, and is especially recommended as a floor material.

[1] *Engineering and Mining Journal*, Aug. 30, 1902.

IRON AND STEEL

By [illegible]

[illegible] States during 1917 showed a demand [illegible] exceeded the record figures of 1916. Moreover, large as [illegible] did not come up to the demand, and the output of the [illegible] supplemented by imports to an extent which has not been [illegible]

The [illegible] and consumption of iron ore for a series of years [illegible]

[illegible] IRON ORE IN THE UNITED STATES (IN TONS OF 2,240 LB.)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] was [illegible] at a [illegible] in [illegible] of the [illegible] [illegible] at furnaces were [illegible] of the [illegible] [illegible] [illegible] but there was [illegible] [illegible] [illegible]

The Marquette range is wholly in Michigan, the Menominee and Gogebi ranges are partly in Michigan and partly in Wisconsin, and the Vermilion an Mesabi ranges are in Minnesota. Details of the movement will be found on following page.

The shipments from the United States Steel Corporation's mines in 190 amounted to 16,174,473 tons, or 58·6% of the whole. This is apart from 325,4 tons shipped by the corporation from the Pewabic mine, in which the Carneg Co. has a one-half interest, but it includes the 6,882 tons shipped from the Ir Ridge mine of the Illinois Steel Co. in Wisconsin. This mine is remote fro the Lake Superior ranges and has never been included in Lake Superior statistic The total shipments from the Pewabic mine were 530,291 tons.

The base prices for Lake ores, for the season of 1903, have been fixed as fo lows: Mesabi Bessemer.—Basis, $4 per ton, f. o. b. lower lake ports; guarant 63% Fe, 0·045% P, 10% H_2O.

Mesabi Non-Bessemer.—Basis, $3·20 per ton, f. o. b. lower lake ports; gua antee 60% Fe, 12% H_2O.

Divided into three classes, according to structure, as follows: Difference b tween first and second class, 15c. per ton, and differential between second a third class 10c. per ton, or a total of 25c. per ton between first and third cla Guaranteed upon Longyear 58% Fe and 10% H_2O, making the latter ore $3· per ton, f. o. b. lower lake ports. The classes are arranged as follows:

First Class.—Stevenson, Wallace, Admiral, Pearce, Cass, La Belle, Elba, Fra Biwabik, Butler, Steese, Hale, Kanawha, Longyear, Morrow, Croxton, Leetoni La Rue, Kinney, Top Brown, Atlas, Cypress, Grant, Laura, Winifred, Victori Shilling Columbia, Columbia, Franklin, Leonard.

Second Class.—Commodore, Union, Petit, Malta, Sparta, Corsica, Minorc Lincoln, Jordan, Beaver, Albany.

Third Class.—Mahoning and Vulcan.

Old Range Bessemer.—Basis, $4·50 per ton, f. o. b. lower lake ports; guara tee, 63% Fe, 0·045% P, 10% H_2O.

Old Range Non-Bessemer.—Basis, $3·60 per ton, f. o. b. lower lake port guarantee, 60% Fe, 12% H_2O.

These prices are substantially the same as for 1902. Less than 35% of th Lake ore is now sold, however, the balance being mined directly by the compani which use it.

Imports of iron ore, other than from Cuba in 1902 included 209,485 ton from Canada, chiefly from the Michipicoten Range on the northern shore of Lak Superior; and 11,000 tons from Newfoundland. The balance was principall Spanish ore, though some cargoes were received from Algeria and Greece, an one cargo from Venezuela.

The following companies shipped iron ore to the United States in 1902: Th Juragua Iron Co., Ltd., 221,039 gross tons; the Spanish-American Iron Co 455,105 tons; the Cuban Steel Ore Co., 23,590 tons; total shipments, 699,73 tons. The Cuban Steel Ore Co. went out of business at the end of the year an its mines are closed. No iron ore was shipped from Cuba in 1902 to any countr *other than* the United States.

The subjoined table gives the production of pig iron by States in 1901 and 1902, in the order of their prominence in 1902:—

States—Long Tons.	1901.	1902.	States—Long Tons.	1901.	1902.
Pennsylvania	7,343,257	8,117,890	New Jersey	155,746	191,380
Ohio	3,536,425	3,631,388	West Virginia	166,597	183,005
Illinois	1,596,850	1,730,220	Michigan	170,762	155,213
Alabama	1,225,212	1,472,211	Kentucky	68,462	110,735
Virginia	448,662	537,216	North Carolina and Georgia	27,333	32,315
New York	283,662	401,369	Connecticut	8,442	12,085
Tennessee	337,139	392,778	Massachusetts	3,386	3,389
Maryland	303,186	303,229	Texas	2,273	3,085
Wisconsin and Minnesota	207,551	273,987			
Missouri, Colorado and Washington	203,409	269,930	Total	15,878,354	17,821,307

All the above-named States, with the exception of Massachusetts and Michigan, made more pig iron in 1902 than in 1901.

The consumption of pig iron in the last five years is approximately shown in the subjoined table, the comparatively small quantity of foreign pig iron held in bonded warehouses not being considered. Warrant stocks are included in unsold stocks:—

ANNUAL CONSUMPTION OF PIG IRON IN THE UNITED STATES, 1898-1902. (IN TONS OF 2,240 LB.)

Pig Iron.	1898.	1899.	1900.	1901.	1902.
Domestic production	11,773,934	13,620,703	13,789,242	15,878,354	17,821,307
Imported	25,152	40,898	52,565	62,980	625,393
Stocks unsold Jan. 1	874,978	415,333	68,309	446,020	70,647
Total supply	12,674,064	14,076,429	13,910,116	16,387,304	18,517,337
Deduct stocks Dec. 31	415,333	68,309	446,020	78,647	49,951
Also exports	253,057	228,678	286,687	81,211	27,497
Approximate consumption	12,005,674	13,779,442	13,177,409	16,232,446	18,439,889

It will be observed that while the increased production of pig iron in 1902 over that of 1901 was 1,942,953 tons, the increased consumption was 2,207,453 tons. The increased consumption in 1901 over that of 1900 was 3,055,037 tons, but the consumption in 1900 was actually less than that in 1899.

For two years past the Association has collected additional statistics, grading the iron made into nine classes. The subjoined table shows the classification made and the quantities produced:—

PIG IRON PRODUCTION BY GRADES. (IN LONG TONS.)

Grades.	1901.	1902.
Bessemer and low-phosphorus pig iron	9,596,798	10,898,166
Basic pig iron made with mineral fuel	1,548,850	2,088,580
Forge pig iron	639,454	823,098
Foundry pig iron	3,548,718	3,651,276
Malleable Bessemer pig iron	256,538	311,458
White and mottled and miscellaneous grades	87,964	172,065
Spiegeleisen	221,882	168,408
Ferromanganese	59,639	44,573
Direct castings	8,562	8,056
Total	15,878,354	17,821,307

The output of the two chief States—Pennsylvania and Ohio—is further given by districts, as follows:—

	1890.	1900.	1902.
Pennsylvania:			
Lehigh Valley	7·9	4·0	3·9
Schuylkill Valley	5·9	3·2	2·9
Upper Susquehanna Valley	2·0	1·0	0·6
Lower Susquehanna Valley	5·5	3·9	3·0
Juniata Valley	2·1	0·9	1·1
Shenango Valley	6·5	5·8	7·0
Allegheny County	14·5	22.6	23·9
Miscellaneous Bituminous	3·4	4·7	4·7
Charcoal	0·2	.....	.....
Total Pennsylvania	48·0	46·2	45·5
Ohio:			
Hanging Rock Bituminous	1·0	1·8	1·8
Mahoning Valley	5·4	7·3	8·1
Hocking Valley	0·9	0·4	0·2
Lake Counties	.....	3·6	4·8
Miscellaneous Bituminous	6·0	4·8	5·4
Hanging Rock Charcoal	0·2	0·1	0·1
Total Ohio	13·5	17·9	20·4

On the changes shown the *Iron Trade Review* comments as follows: "It is somewhat surprising to note that much of the movement of the decade from 1890 to 1900 has been almost reproduced in the short space of two years. It is not a result which would have been expected on purely theoretical grounds. Last year was one which kept in operation furnaces located in districts, which only figure in abnormal times. When the next depression strikes the trade we may expect radical changes to be shown up by our method of comparison. But for the present we would hardly expect that the State of Virginia, for example, should produce a smaller percentage of the total production in 1902 than in 1900 or even in 1890, but such is found to be the fact. And the same movement is found with West Virginia, Tennessee and New Jersey. Every one of these States produced more pig iron in 1902 than in either 1900 or 1890, and their relative decline is shown only by a comparison of percentages.

"Interest will, of course, center on the large iron States. We find that the great State of Pennsylvania, which made 48% of the pig iron production in the United States during 1890, and declined to 46·2% in 1900, experienced a further drop to 45·5% in 1902. Looking at the districts, however, the decline is easily located in the eastern part of the State. The upper Susquehanna Valley has about dropped out, while the lower has kept about even as to tonnage. The Lehigh, Schuylkill and Juniata valleys have slightly decreased their actual tonnage, and greatly decreased their proportion.

"Against these declines in the eastern part of Pennsylvania, there have been almost proportionately large advances in the western part, using Lake ores entirely. Allegheny County, which made 14·5% of the country's production in 1890, made 23·9% in 1902. The tonnage was more than tripled in 12 years while the country scarcely doubled its tonnage. The Shenango Valley increased its relative importance in the same period, in less degree.

"In Ohio, the Mahoning Valley and the Lake counties increased their relative proportion in a substantial way, and made the whole State more important relatively.

hearth steel is used for structural material, shapes and sheets. It may be noted however, that the latest rail mill built—that at Ensley, Ala.—uses basic open hearth metal. That plant, however, made very few rails last year, having been completed near the close of the year.

It is worth noting also that the greater part of the additional output of open-hearth steel is from the basic furnaces. Of the steel made last year in the open-hearth furnace 79·1% was basic and 20·9% acid steel; the proportions in 1901 being 77·7% and 22·3% respectively. The Bessemer, or converter, production continues to be practically all acid steel, and the basic converter does not come into use here. The proportions of acid and basic steel made are shown in the following table:—

	Acid.		Basic.		Total.
	Tons.	%	Tons.	%	Tons.
Bessemer	9,306,471	61·6	.....	.....	9,306,471
Open-hearth	1,191,196	7·9	4,496,533	29·7	5,687,729
Crucible	125,000	0·8	.....	.....	125,000
Totals	10,622,667	70·3	4,496,533	29·7	15,119,200
Totals, 1901	9,254,602	73·1	3,618,993	26·9	12,873,595

The increase last year, as compared with 1901, in acid open-hearth steel was only 14·7%, while that in basic steel was 24·2%. This increase will be augmented by the extension of steel making in the South, where several new plants are being erected and others are contemplated. All of these will naturally make basic steel.

The figures given, emphasize the movement of several years past, and again show that the open-hearth process is growing in importance in this country. This is further shown by the fact that nearly all the new steel plants are open hearth furnaces. The only important new Bessemer plant now under construction is that of the Lackawanna Steel Co. at Buffalo; and that is not wholly an addition to the converter capacity, since it takes the place of the smaller plant at Scranton, which the company dismantled last year.

Finished Iron and Steel.—The production of all kinds of Bessemer steel rails by the producers of Bessemer steel ingots in 1902 was 2,876,243 gross tons as compared with a similar production in 1901 of 2,836,273 tons, in 1900 of 2,361,921 tons, and in 1899 of 2,240,767 tons. The maximum production of Bessemer steel rails by the producers of Bessemer steel ingots was reached in 1902, but the increase in that year over 1901 amounted to only 40,020 tons, or 1·4%. As compared with 1887, 15 years ago, the increase in 1902 in the production of Bessemer rails amounted to only 831,474 tons, or 40%, while during the same period the increase in the production of Bessemer ingots amounted to 6,202,330 tons, or almost 211%.

With the exception of the Lackawanna plant at Scranton, which was dismantled in 1902, all the Bessemer rail mills were operated nearly to their full capacity in that year, the demand for steel rails being greater than the supply all through the year. Some interruption to the utmost possible activity of the Bessemer rail mills in 1902 was also caused by the inability of the railroads to deliver raw materials promptly to the blast furnaces.

1,178,424 kegs, or over 12%. In 1900 the production amounted to 7,233,979 kegs, in 1899 to 7,618,130 kegs, in 1898 to 7,418,475 kegs, in 1897 to 8,997,245 kegs, in 1896 to 4,719,860 kegs, and in 1895 to 5,841,403 kegs. The total production of cut nails in 1902 was 1,633,762 kegs of 100 lb. each, as compared with 1,542,240 kegs in 1901, an increase of 91,522 kegs, or almost 6%. In 1886 the maximum production of 8,160,973 kegs was reached. In 1902 the production of wire nails exceeded that of cut nails by 9,348,484 kegs, in 1901 by 8,261,583 kegs, in 1900 by 5,660,485 kegs, in 1899 by 5,713,790 kegs, in 1898 by 5,846,254 kegs, and in 1897 by 6,890,446 kegs.

One branch of iron manufacture has almost ceased to exist. In 1902 there were no forges in operation in the United States for the manufacture of blooms and billets directly from the ore. In 1901 the blooms and billets so made amounted to 2,310 gross tons, as compared with 4,292 tons in 1900, 3,142 tons in 1899, 1,767 tons in 1898, 1,455 tons in 1897, 1,346 tons in 1896, 40 tons in 1895, 40 tons in 1894, 864 tons in 1893, and 2,182 tons in 1892. All the ore blooms produced since 1897 were made by the Chateaugay Ore & Iron Co., of Plattsburgh, New York, at its Standish Iron Works, which were, however, idle in 1902.

The iron blooms produced in forges from pig and scrap iron in 1902, and which were for sale and not intended for the consumption of the makers, amounted to 12,002 gross tons, as compared with 8,237 tons in 1901, 8,655 tons in 1900, 9,932 tons in 1899, 6,345 tons in 1898. All the pig and scrap blooms made in forges from 1895 to 1902, and intended to be for sale, were made in Pennsylvania and Maryland.

The United States Steel Corporation.—As the United States Steel Corporation, the organization of which was noted and described in THE MINERAL INDUSTRY, Vol. X., now produces over 50% of the pig iron manufactured in the United States, and over 60% of the steel and finished products, its report for 1902 constitutes an important part of the history of the iron trade for the year. An analysis of this report is given in the following pages and contains very full information as to the operations of the company. It covers the calendar year 1902.

The balance sheet, summed up and reduced to its closest possible analysis, shows assets and liabilities as below:—

Common stock	$508,302,500	
Preferred stock	510,281,100	
Stocks of subsidiary companies	215,914	
		$1,018,799,514
Bonds, U. S. Steel Corporation	$301,069,000	
Obligations of subsidiary companies	69,285,878	
		$370,344,878
Sinking and other special funds		22,699,988
Current accounts and liabilities		49,695,253
Surplus fund		77,874,597
Total liabilities		$1,546,544,234
Properties owned and improvements		$1,388,446,345
Sinking fund and miscellaneous		2,283,734
Inventories, material on hand		104,380,345
Accounts, bills and collectable assets		60,280,140
Cash on hand		50,153,773
Total assets		$1,546,544,234

To put it briefly, the company has, in capital stock, $1,018,799,514, on approximately half of which it has agreed to pay 7% yearly, before the other half

others in that form, and does not include billets made and afterward conver into other products in the company's mills:—

	Long Tons.	Per Cent.
Billets and blooms sold and shipped	782,637	9·5
Rails	1,920,786	23·4
Merchant steel, bars, shapes, etc	1,254,560	15·3
Plates	649,541	7·9
Sheets and tin-plates	768,576	9·6
Wire and wire products	1,122,809	13·7
Wire-rods	109,330	1·3
Tubes and pipes	744,062	9·1
Axles	136,767	1·7
Spikes, bolts, nuts, etc	42,984	0·5
Rail-joints and angle-bars	139,954	1·7
Structural work (Am. Bridge Co.)	481,029	5·9
Miscellaneous	29,177	0·4
Total finished products	8,197,232	100·0

Only 9·5% of the steel made was sold in the comparatively crude form of b lets. The table shows the wide range of products made in the company's v rious mills.

The tonnage of unfilled orders on the books at the close of 1902 equal 5,347,253 tons of all kinds of manufactured products. At the corresponding d in preceding year the orders booked equaled 4,497,749 tons. In many of t classes of heavier products, like rails, plates and structural material, practica the entire capacity of the mills is sold up until nearly the end of the year 1903.

The income account for the year—condensed as far as possible—may be giv as follows:—

Gross sales and earnings	$560,510,479
Rentals and miscellaneous	3,128,971
Interest on investments and receipts from companies controlled	5,426,452
Total receipts	$569,065,902
Manufacturing cost and operating expenses	$411,408,818
Selling, general and transportation expenses	13,202,399
Taxes, discounts and current interest	4,299,494
Rentals and interest, subsidiary companies	6,846,427
Total expenses	$435,757,138
Net earnings	$133,308,764
Depreciation and replacement funds, regular	$14,150,825
Depreciation and replacement funds, extraordinary	10,000,000
Interest on U. S. Steel Corporation bonds	15,187,850
Sinking fund on Corporation and subsidiary bonds	3,664,064
Total charges	$43,002,289
Net balance for stock	$90,306,595
Dividends paid, 7%, on preferred stock	$35,720,178
Dividends paid, 4%, on common stock	20,332,690
Total dividends	$56,052,868
Undivided profits, to surplus	$34,253,657

Had all the net earnings shown been applied to dividends, they would ha been sufficient to pay 10·74% on the common stock. The sum available for di dends was 15·84% of the gross receipts. In this case it is impossible to ma any close averages of production; it may be stated, however, that the gross sa and earnings showed approximately $68·37 per ton of finished steel product, a the total receipts $69·42 per ton. The manufacturing expenses were $50·19, a the total expenses $53·16 per ton.

portation properties, to secure material reduction in cost of manufacture, transportation of raw and unfinished material, and distribution of finished product, etc.

The outlays as above are classified by properties as follows: Acquirement of stocks of subsidiary companies, $258,473; manufacturing properties, $9,743,190; ore properties, $1,971,542; coal and coke properties, $2,043,169; transportation properties, $2,741,653; total, $16,757,963. Against this there was a credit of $171,430 on miscellaneous properties sold; leaving a net outlay of $16,586,533, as above.

The average number of employés in the service of all properties during the entire year was 168,127. The aggregate amount paid for salaries and wages of employés was $120,528,343.

One of the most important points to be considered in the trade in 1902 was the course of the United States Steel Corporation as to the extension of its operations. During the greater part of the year the corporation was quiet in this direction, and little was heard of any further additions to its properties, its apparent policy having been simply to round out and complete the works which it already owned, particularly by the addition of blast furnace capacity. It will be remembered that the number of blast furnaces owned by the big corporation on its first organization was not sufficient to supply its steel works with pig iron, and the consequence was that heavy purchases of pig iron had to be made from time to time. This outside buying was chiefly done from the Bessemer Steel Association, the organization of the blast furnace operators of the Mahoning and Shenango valleys, in western Pennsylvania and Ohio. Apparently the corporation did not intend to enlarge the number of its plants or possibly postponed any such action until the settlement of the litigation in which its proposed issue of $250,000,000 in bonds was involved. In December, however, there was a sudden change in this respect, and it was announced that the corporation had purchased the property of the newly formed Union Steel Co., which was a consolidation of the Union Steel Co., which, during the year, had been constructing blast furnaces and steel works at Donora, near Pittsburg, and of the Sharon Steel Co., which owned comparatively new works of the best modern types at Sharon, Pa. The purchase included the transfer of all the property and assets of the Union Co., comprising, besides the works above mentioned, large interests in iron ore on the Menominee and Mesabi ranges, in the Lake Superior region, and also a large working capital which had been provided by the stockholders. The price paid was $45,000,000, payment being made in bonds secured by mortgage upon the properties turned over. It may be said that there were special reasons for the acquisition of these properties. In the first place they gave the corporation an important addition to its blast furnace capacity. Beyond that, however, they put an end to the prospect of a serious competition in the wire and nail trades, and strengthened the United States Steel Corporation on a side where it had been particularly weak, and open to attack. The result in this direction will probably be the closing of some of the older works of the company and the transfer of a portion of the wire business of the Donora and Sharon mills. Beyond the points mentioned, however, a strong motive for the purpose is found

Imports and Exports.—The results of the enormous home consumption in 1901 were apparent in a diminution of exports and an increase in imports. The demand and prices at home made it difficult to compete with Great Britain and Germany in foreign markets; while large quantities, especially of pig iron, scrap and steel billets, were absorbed by our manufacturers.

The preceding table, compiled from the reports of the Bureau of Statistics of the Treasury Department, gives the quantities of leading articles of iron and steel imported into the United States in the four calendar years 1899, 1900, 1901 and 1902.

The total imports of iron and steel, including machinery, cutlery, firearms, etc., for which weights are not obtainable, amounted in foreign value to $41,468,826 in the calendar year 1902, as compared with $20,395,015 in 1901, $20,443,911 in 1900, and $15,800,579 in 1899, an increase in 1902 as compared with 1901 of $21,073,811, or over 100%. Of the pig iron imported in recent years a large part was spiegeleisen and ferromanganese, which pay duty as pig iron, but in 1902 there was a great increase in the importations of foundry and Bessemer pig iron.

The following table, also compiled from the reports of the Bureau of Statistics of the Treasury Department, gives the exports of leading articles of iron and steel in the calendar years 1899, 1900, 1901 and 1902:—

EXPORTS OF IRON AND STEEL, 1899—1902. (IN LONG TONS.)

Article.	1899.	1900.	1901.	1902.
Pig iron	228,678	286,687	81,211	27,487
Scrap and old, for remanufacture	76,663	40,328	14,199	9,411
Bar iron	10,898	13,299	17,708	22,949
Band, hoop, or scroll iron and steel	2,869	2,976	1,561	1,674
Bars or rods of steel not wire rods	80,429	81,366	27,397	9,300
Steel wire rods	16,992	10,652	8,165	24,613
Billets, ingots, and blooms	25,487	107,385	28,614	2,409
Cut nails and spikes	9,974	11,163	9,302	7,170
Wire nails	33,517	27,404	18,778	26,580
All other nails, including tacks	2,076	1,812	1,806	2,944
Iron plates and sheets	6,196	9,381	6,900	3,434
Steel plates and sheets	50,635	45,584	23,923	14,866
Iron rails	6,442	5,374	901	211
Steel rails	271,272	356,245	318,055	67,455
Structural iron and steel	54,244	67,714	54,005	53,859
Wire	116,317	78,014	88,238	97,943
Total	942,689	1,154,284	700,857	370,805

The total exports of iron and steel, which include locomotives, car wheels, machinery, castings, hardware, saws and tools, sewing machines, stoves, printing presses, boilers, etc., amounted in the calendar year 1902 to $97,892,036, as compared with $102,534,575 in 1901, $129,633,480 in 1900, $105,690,047 in 1899, $82,771,550 in 1898 and $62,737,250 in 1897. The exports of iron and steel more than doubled in value from 1897 to 1900, but there was a shrinkage in 1901 as compared with 1900 of $27,098,905, or more than 20%. In 1902 there was a further shrinkage, but it was not so pronounced as in 1901, owing to the advance in prices.

The exports of agricultural implements, which are not included above, amounted in the calendar year 1902 to $17,981,597, as compared with $16,714,308 in 1901, $15,979,909 in 1900, $13,594,524 in 1899, $9,073,384 in 1898, and $5,302,807 *in 1897.*

THE IRON AND STEEL MARKETS IN 1902.

The consumption of iron and steel in the United States continued throughout 1902 to be on a scale altogether unexampled in history. In fact, the year seemed to be the culmination of a continued period of prosperity. The continuance of good crops for several years, coupled with comparatively short crops in Europe, created a demand abroad for our agricultural products, which brought into the United States an enormous amount of money, and furnished people with funds for building and for investment in enterprises of various kinds, thereby creating a demand for material which showed no signs of slackening during the year. Building in all of the large cities was on an enormous scale, and there was a continuance of the tendency shown for several years to increase the use of iron and steel in building construction. The railroad demand which was at one time considered the chief factor in the iron trade, is now of much less relative importance than formerly, although the quantity actually consumed by the railroads has largely increased during the year. The general prosperity of the country enabled the railroads to make renewals very freely, and to enter on many schemes of improvement and new construction in order to enable them to handle traffic more conveniently and more cheaply. This involved the use of large quantities of new rails, bridge steel and the like, while new equipment also absorbed additional quantities. The new railroads built in the United States during 1902 amounted, according to a statement prepared by the *Railroad Gazette*, to 6,024 miles, which is the largest report made for more than eight years past. Notwithstanding the large quantity of steel required for this purpose, it was very much less than that taken for renewals for new sidings and additional tracks on the more important lines. The construction of electric railroads also was very active during the year, and the material required with these enterprises formed a large item of the demand. Girder rails which are generally used for these roads, in fact, were turned out by the rail mills to an extent never before reached.

Almost immediately after the opening of 1902 the rush for material began, and by the end of January the capacity of blast furnaces and rolling mills was pretty fully taken up for the first half of the year. At the same time, the rail mills were completely filled for the year, and some important orders from Mexico and South America, which were offered here, were refused, owing to the inability of the makers to fill them, and went finally to English and German mills. All through the first part of the year the demand continued large, and in February a new and more special pressure for foundry iron began. It seemed as though a number of the larger consumers had up to that time either been doubtful as to the continuance of high pressure conditions in the trade, or had been too confident of their supplies, for in that month a number of them came into the market to an extent which for the time being threatened general demoralization. The immediate pressure, however, was averted for the time by offers of Scotch and Middleboro iron from Great Britain and of German pig, while at the same time a number of large contracts were made which filled the order-books of the furnaces for the third quarter, and in some cases went into the fourth quarter of the year.

Under ordinary conditions this state of affairs would have resulted in a sharp

before this time were compelled to postpone construction until a more convenient season. Railroads were generally able to secure the supplies they needed in some shape or other, but, trolley enterprises and new building suffered considerably. In structural steel especially, some large purchases were made during the latter half of the year from middlemen or others who held contracts with the mills, and in these cases a considerable advance upon the current quotations was paid.

During the last half of the year conditions remained the same. The history of the trade was a continual struggle to secure material, and to keep up with contracts for delivery, and the position was complicated by the fact that the railroads were handling an unprecedented amount of traffic in all directions, so that annoying delays and blockades were frequent. Fuel, ores and other raw materials did not reach furnaces and mills, and they were unable to clear their yards of finished material for which consumers were waiting. It is only justice to say that the leading railroad lines made every effort to put an end to this condition of affairs, and to handle their traffic as promptly as possible, but most of them seemed to have underestimated probable demands, and from every quarter there came complaints of shortage of cars and motive power. It can hardly be said that there was any improvement in this direction up to the end of the year.

Alabama.[1]—The conditions in the Birmingham iron market, including the entire iron region of Alabama and the adjacent States, were extremely active throughout the year. Production was on an unexampled scale. Not a single iron company in Alabama failed to make money in 1902. These profits have not all appeared in dividends, as a large part of the money was wisely expended in improving the properties and accumulating a good working surplus. Not only was all the iron produced during the year sold, but, in fact, many of the companies closed the year with a shortage on their contract deliveries. This was not due so much to any trouble at the furnaces as to the ore shortage which, during the last three months of the year, considerably embarrassed the iron manufacturers. Moreover, nearly every blast furnace in this section has nearly, if not quite all its product for the first half of 1903 under contract. A great deal more could have been sold for later deliveries, but many of the furnaces were unwilling to take orders running beyond June, believing that they did better by adhering to this course.

The closing quotations for pig iron were as follows: No. 1 foundry, $21@$22; No. 2 foundry, $20@$21; No. 3 foundry, $18·50@$19·50; No. 4 foundry, $17@$18; gray forge, $16·50@$17; No. 1 soft, $21@$22; No. 2 soft, $20@$21. Prices for the first half of the year will not fall below $20 for No. 2 foundry. All deliveries on old contracts at lower prices have now been worked off and there is little doubt that the average realized by Alabama blast furnaces during 1903 will be at least $18, taking all grades into account.

The rolling mills in the Birmingham district were actively employed throughout the year, and nearly all of them closed the year with large orders on hand for 1903. Foundries and machine shops in the district did also exceedingly well. At the Ensley steel plant work was good. The completion of the rail mill will require a large quantity of steel, especially as the plant had orders for rails well

[1] By L. W. Friedman.

1913 The steel, wire rod and nail mills had no room for complaint over during the year.

[illegible] continued to come forward. The Tennessee Coal, Iron & Railroad completed an additional stack at the Alice Furnace, while the Alabama [illegible] & Iron Co. started a new stack at Gadsden. Rising Fawn Furnace of the Georgia Coal & Iron Co., which had been dismantled for several years past, was rebuilt as a coke furnace, and put in blast. Projects for several more were started, and arrangements made to build at least three additional.

[illegible] in 1907 strengthened its position as a distributing market [illegible] of the Central West, remaining the center from which was [illegible] movement of iron ore from the Lake Superior region. Sales of iron ore [illegible] to carry the product down the lakes, developed later in the season for some time past. The opening of spring found iron [illegible] established as to a price policy for the season. The old range [illegible] a stable list of prices and felt that they ought to obtain a [illegible] premium in view of its increasing scarcity. The Mesabi producers [illegible] declined to advance prices and make a general grab for all [illegible] at the same time there existed a desire to increase profits by lowering costs. It was generally believed that the time had come for an organized [illegible] and output. A general survey of the field, however, soon [illegible] unfavorable. The old range men therefore asserted the [illegible] year. 51.5% for Bessemer grades while the Mesabi range men [illegible] Bessemer Mesabi, 51.5% and on non-Bessemer Mesabi [illegible] Bessemer [illegible] the same prices as Bessemer Mesabi [illegible]

[illegible] W. A. Harris A[illegible]

[illegible]

* [illegible]

of a fight over going rates through the year. Some vessel interests refused handle anything but wild ore rather than take the proposed smaller rates; u fortunately for them the season opened early. Almost the entire fleet of t United States Steel Corporation was in operation by April 10, before contr rates for the season had been determined. The outside vessel men had hoped th boats would not start before May 1. The sudden opening of navigation and t movement of 1,500,000 tons of ore before the vessel men expected any ore to delivered at all, upset plans generally. In round numbers it has been figured th the amount of ore handled over Lake Erie docks was 22,640,000 tons, as compar with 17,014,000 tons for the season of 1901, an increase of 5,626,000 tons. T quantity which remained on the docks Dec. 1, 1902, was 7,074,250 tons, as co pared with 5,859,653 tons on Dec. 1, 1901, an increase of 2,214,597 tons. 1902 most of the boats made an average of 20 trips for the season, whereas t lowest average heretofore was about 22 trips, a decrease of 11%. Had the c shortage been responsible for vessel delays the quantity of ore moved from t lake docks to furnaces would not have shown such an abnormal percent. of t total increase handled. The quantity of ore moved shows that the railroads d extraordinary work. Ore shippers had no reason to complain of lack of cars poor dock equipment. In one instance a new automatic unloader handled 5,6 tons in five hours and 15 minutes, 92% of the cargo being taken out automatical Nor can blame for delays be placed on dock conditions since the entire year w free from labor difficulties.

The hard coal strike immediately threw vessels loading anthracite at Buffalo a Erie to the bituminous shipping ports. These boats not finding their usual nu ber of up-bound cargoes began going back to the head of the lakes light and rus ing down ore. The result was a general congestion at lower lake docks, whi lasted nearly all summer. The expected importations of ore from the Michip coten ore fields in Ontario were estimated at 1,000,000 tons. Instead they pe haps have reached 200,000 tons, an increase of 60,000 tons, or 10 cargoes, ov 1901. The increased demand for ore in Canada, the partial failure of some pro ects there and the inferior grade of the ore may have had something to do wi keeping down importations.

The following table, prepared by the Cleveland *Iron Trade Review,* shows t performances of docks at the head of the lakes:—

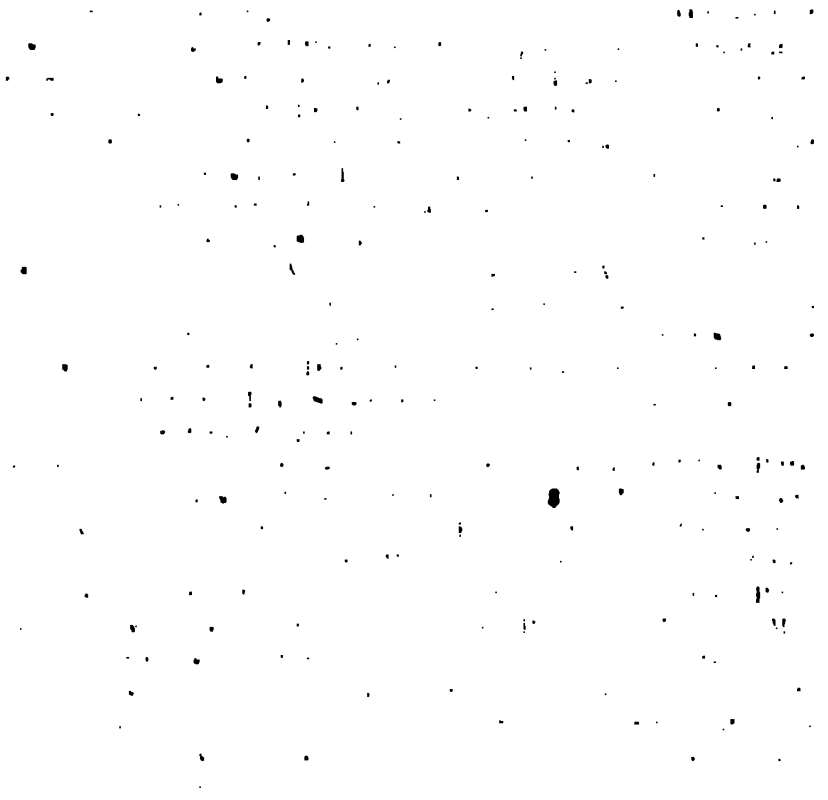
	1901.	1902.	Changes.
Escanaba	4,022,668	5,413,704	I. 1,391,0
Marquette	2,354,284	2,595,010	I. 240,7
Ashland	2,886,252	3,553,919	I. 667,6
Two Harbors	5,018,197	5,606,185	I. 588,9
Gladstone	117,089	92,375	D. 24,7
Superior	2,321,077	4,180,568	I. 1,859,4
Duluth	3,437,955	5,598,408	I. 1,160,4
Total by lake	20,157,522	27,039,169	I. 6,881,6
Total, all rail	431,715	500,000	I. 68,2
Total shipments	20,589,237	27,539,169	I. 6,949,9

The following tables show the quantity handled over Lake Erie docks, a those remaining there in stock on Dec. 1, the close of the navigation year:—

The basic producers, who had been expecting higher prices to counteract a long suspension of operations, began about Feb. 1 to sell iron for the future, evidently believing that the top had been reached. They sold iron for third-quarter delivery at the market price of $17·50, Valley furnace. Before the first week in February had passed one furnace announced that it had sold up its entire supply of foundry iron for the year at current prices of $16·50 for No. 1 foundry, Valley furnace. Such an announcement, however, seldom means more than two-thirds of the possible output, the remaining one-third capacity being reserved to accommodate old customers, to provide against emergencies or to obtain possibly higher prices.

The business for the year was mostly done before March 1, and the worst operating conditions of the first nine months came during the time the sales were being made. Early in March there was a slight setback on account of floods, which temporarily crippled railroads. The increasing demand for pig iron advanced prices to $17·50 for No. 2 foundry, with premiums for immediate shipment. Toward the end of the month Bessemer and basic producers began to show signs of parting company. The basic producers justified their grab-all policy by saying that they had to make up for the long idleness of their stacks. Bessemer producers began to try to curb the grasping market spirit, and the Bessemer Association held for $16, with basic producers demanding $17, Valley furnace. The beginning of May found foundry iron commanding $20 in the valleys. The quantity of foundry iron sold at this price for early delivery was very small. The strike of the hard coal miners did not affect the pig iron trade for a month, but the demand of furnace workmen in the Mahoning and Shenango valleys, and at some furnaces in Southern Ohio and the Pittsburg district for an 8-hour day instead of one of 12, with no change in wages, caused a strike of a week's duration early in June. It was settled by a 10% increase in wages. Demand was now so near supply that an order for 100 tons of foundry iron had to be divided among three furnaces in the South, the price paid being $16·50, Birmingham. For immediate shipment foundry iron was bringing $22·50, and an offer of $20 for Bessemer iron in this market failed to get a carload. This represented conditions up to July. Foundry prices were up to $21 for third quarter delivery with Bessemer holding at $21·75. When the strike was over and the men returned to work with a 10% advance in wages, the Bessemer and basic producers found trouble ahead, production began to decline and consumers to suffer. There was a demand for material for delivery during 1902, and the first quarter of 1903. Bessemer iron for first quarter delivery sold at $16·50.

The strike of the miners in the Pocahontas district and the resulting coke shortage shut down 12 furnaces in the Southern Ohio district and some near Pittsburg district. By August foundry iron for immediate shipment commanded $24@$25, with buyers eager to get it, and by September sales of foundry grades were developing for the first quarter of 1903. Prices for immediate shipment climbed higher and higher, until foreign producers were able to ship to the Mahoning and Shenango valleys and the Pittsburg district. Early in October foreign iron began to arrive, and to the end of the year the needs of the market not *supplied* by contracts were met very largely by importations from Scotland and *Nova Scotia*. The demand for foundry iron advanced prices to $27@$28 for



would not release billets and sheet bars. With importations of material the home market eased up considerably, and there has been no such shortage since.

To the end of the year there was a marked difference between the heavier and the lighter grades, the heavier indicating a buoyant demand for material while the lighter grades showed indications of overproduction. By July 15 the smaller mills which were looking for business were reported cutting prices, but there was no open cutting till September, then the market dropped and struck what seemed to be the bottom price for material out of stock as the January basis, of 3·10@3·20c. for No. 27 was re-established. The question arose with the cut in prices whether the United States Steel Corporation was not trying either to drive its smaller competitors out of business or force them into a combination where they could be more easily controlled. Many such producers, not able to have their own mines, blast furnaces, steel mills and rolling mills, are at the mercy of producers of billets and bars. The year was one of policy making, and during it the policy of making the supply of material at all times equal to the needs but not in excess of them, was introduced.

Plates and Structural Material.—The year hardly showed a waver in the heavy steel trade. It opened with large stocks of both structural shapes and plates on hand. Early buying was heavy and continued good all spring, with no distress until April. Jobbers by Feb. 15 were getting 2·25c. for all grades, with demand rather brisk. The March floods hampered the steel mills considerably, and lessened production for a couple of weeks. The demand for shapes increased, and prices began to range between 2·25c. and 3c. out of stock. By the latter part of March speculators thought to get a lead on the future by buying heavily, but the mills gave immediate notice that no material should be sold to speculators on any pretext whatever. This policy was followed through the year. By May 1 the structural consumers began to inquire abroad for material, and it seemed as if ship building in some of the lake yards would have to await the arrival of foreign steel. Under such conditions the smaller mills got restless. They could not see how they were to be helped by conservative prices, and were inclined to break away from the old quotation of 1·60c., Pittsburg. They began to talk premiums, particularly on plate, the demand for which was very heavy. The mills in this territory were sold up for months ahead, and Eastern mills were sold pretty well up to the limit of their capacity. The latter part of May saw the smaller structural mills breaking away from the larger ones on prices for spot shipment. The larger mills had very little to sell, but sold what they could at 1·6c., Pittsburg, the old price. The Eastern structural mills jumped prices to 2·25@3c. for spot shipment, offering considerable quantities. This brought mill and job sales to the same level. By the second week of June the plate pool had been suspended, and the smaller mills refusing to be governed by the conservative price policy, were selling for what the market would stand. They began to demand 1·80c. and 1·90c. at the mill, while the mills in this territory producing structural shapes began to ask 1·90c. at the mill. It is perhaps fortunate that most of the business for 1902 was done before this premium policy was adopted, although the small mills had all they could do to supply home needs at the higher price.

About July 15 importations began and helped out smaller consumers a great

a box also was made, but it was late in the year before enough business was secured to warrant the starting of all of the idle mills. Wire products were cut in price $7 a ton, and the plants all were operated steadily. In sheets a cut of $5 a ton was found necessary to insure business for the mills, many of which had been shut down for lack of orders. The independent plants were not closed by these cuts, as most of them had contracts taken at favorable prices, and had fully provided for the raw material required. While the conditions in these lines appear to have been unsatisfactory the business done, it is estimated, was much heavier than in former years.

The apparent dullness in tin-plate, sheets and wire was almost lost sight of in the tremendous business done in structural material and other finished steel products. Every plant in this district was crowded with orders throughout the year, and a heavy business was booked for this year's delivery, insuring continuous operation up to July 1. Some high prices were paid for finished steel products during the last half, but the official price was maintained at all times by the leading interests. Business accepted at these figures, however, was for extended delivery. The accompanying table of prices for the year merely gives the rates quoted, and does not record the prices paid, as it would be impossible to satisfactorily show the fluctuations on orders for prompt shipment. The ruling price was quoted in every instance, but premiums over these rates were paid on urgent orders, and they varied from $2 to $8 a ton on structural material, steel bars and plates.

AVERAGE PRICES PER TON OF IRON AND STEEL IN PITTSBURG DURING 1902.

	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bessemer pig iron	$16·75	$17·00	$7·50	$20·75	$22·00	$22·25	$22·25	$22·50	$23·00	$24·00	$23·75	$23·50
Foundry No. 2	16·50	17·00	19·00	20·75	21·50	22·00	23·00	23·00	23·00	23·50	23·50	23·25
Gray forge	16·00	16·50	18·00	19·75	20·25	20·50	21·00	21·25	21·50	21·00	21·00	21·00
Bessemer steel billets	27·00	30·00	31·00	32·00	32·50	33·50	32·50	31·00	31·00	30·00	30·00	30·00
Sheets No. 28	3·10	3·10	3·10	3·10	3·10	3·00	3·00	3·00	3·00	2·75	2·75	2·75
Tank plate	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60
Steel bars	1·50	1·55	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60
Steel rails	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00
Wire nails	2·00	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·00	1·90	1·85	1·85
Cut nails	2·05	1·95	1·95	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·05
Ferromanganese, domestic	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50

Importations of steel and pig iron were heavy during the last half, and it would be difficult to give a correct estimate of the tonnage. Prices in most instances were about equal to the rate for the home product. Less Southern iron was received in this district than in former years, indicating that prosperous conditions were not confined to the Pittsburg district alone. The railroads were entirely responsible for the curtailment of the production of pig iron. Furnaces in the Mahoning and Shenango valleys were forced to bank during the last four months of the year, and a number were blown out on account of a shortage of coke. The coke supply was adequate and fully 1,000,000 tons were stocked in the yards during the last half, the railroads being unable to furnish the cars needed to transport it to the furnace. Blast furnaces in the Pittsburg district were not so severely affected, but the production would have been greater had conditions *been better.* Two furnaces were added to the Carrie group early in the second *half, and in* December one was added to the Edgar Thomson group.

The labor troubles of last year were not of a serious character. Strikes of structural iron workers, machinists and of steel melters in the crucible steel works were soon settled by granting advanced wages to the men. The iron workers in the union rolling mills of the country got two advances. The puddlers' pay was increased from $5·50 to $5·75 a ton in January, and the finishers got an increase of 2%. In July the puddlers were given $6 a ton rate, and the finishers an additional 2% increase. This was due to the heavy demand and advanced prices in bar iron. These high wages continued for the remainder of the year.

The Union Steel Co. and the Sharon Steel Co. were consolidated in November, and in the following month the merged company was taken over by the United States Steel Corporation. The St. Clair Furnace Co. and the St. Clair Steel Co., with plants at Clairton, were consolidated, and operated as the Clairton Steel Co. by the Crucible Steel Co. of America.

The beam and plate associations met in December, renewed the agreements for another year and reaffirmed prices.

Iron and Steel Production of the World.

The pig iron production of the world in 1902 is shown in the following table, the figures being reduced to metric tons, to facilitate comparisons:—

PIG IRON PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1898	1,266,388	979,755	69,248	2,525,100	7,215,927	12,287	2,941,200
1899	1,323,990	1,036,185	95,582	2,578,400	7,100,208	19,218	2,708,700
1900	1,311,949	1,161,180	87,612	2,714,298	7,549,655	22,990	2,935,000
1901	1,300,000	765,420	248,896	2,398,823	7,785,587	25,000	2,807,000
1902	1,335,000	1,102,910	324,670	2,427,427	8,402,660	24,500	2,586,000

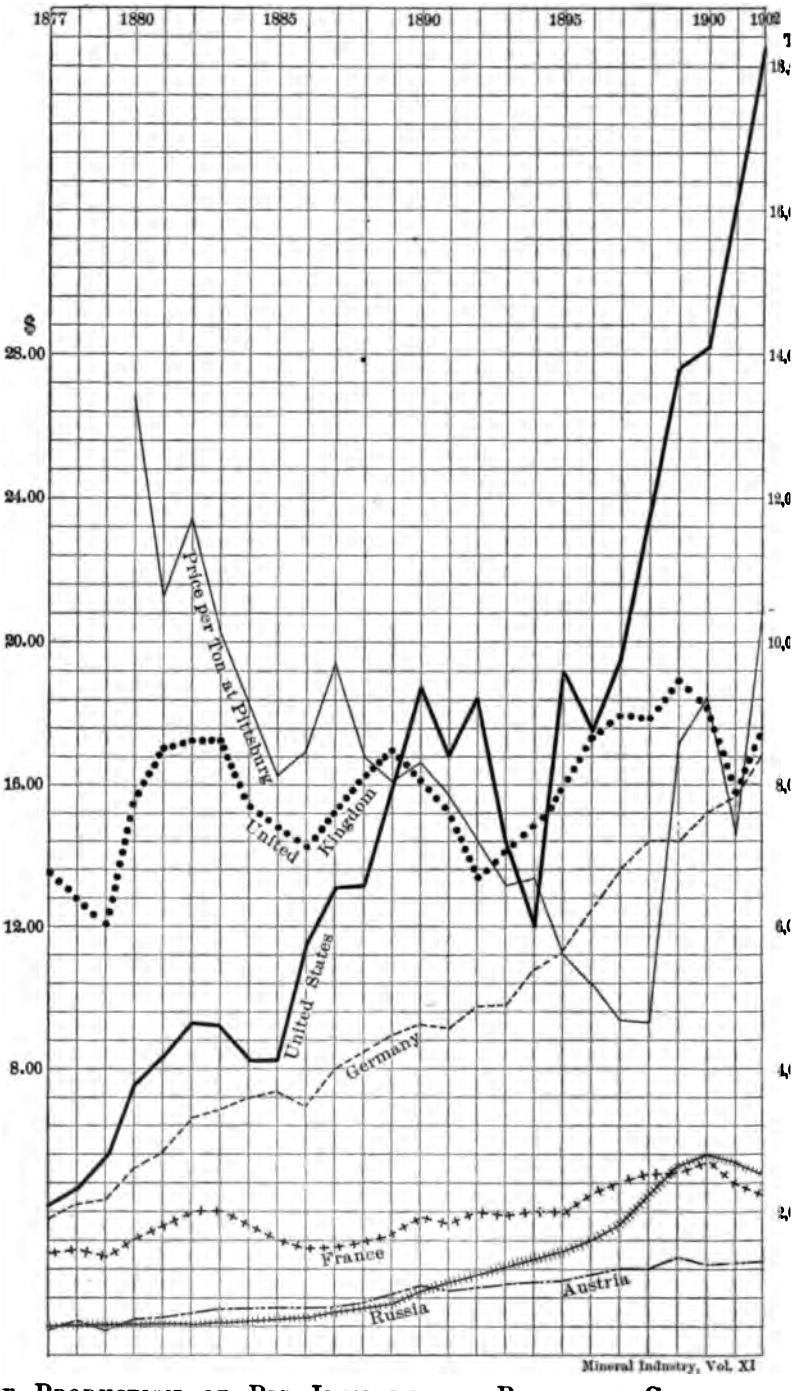
Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1898	229,754	531,766	8,819,968	11,962,317	545,000	39,418,900
1899	260,385	467,737	9,572,178	13,838,634	625,000	39,722,500
1900	289,788	526,868	9,003,046	14,009,870	695,000	40,198,800
1901	294,118	528,375	7,977,459	16,132,408	635,000	40,889,358
1902	278,000	534,400	8,653,976	18,006,448	615,000	44,557,991

The three chief iron-producing countries—the United States, Great Britain and Germany—turned out last year 79% of the world's production of pig iron, as compared with 74% in 1901. The United States alone made 40% of the total in 1902, as compared with 39% in 1901.

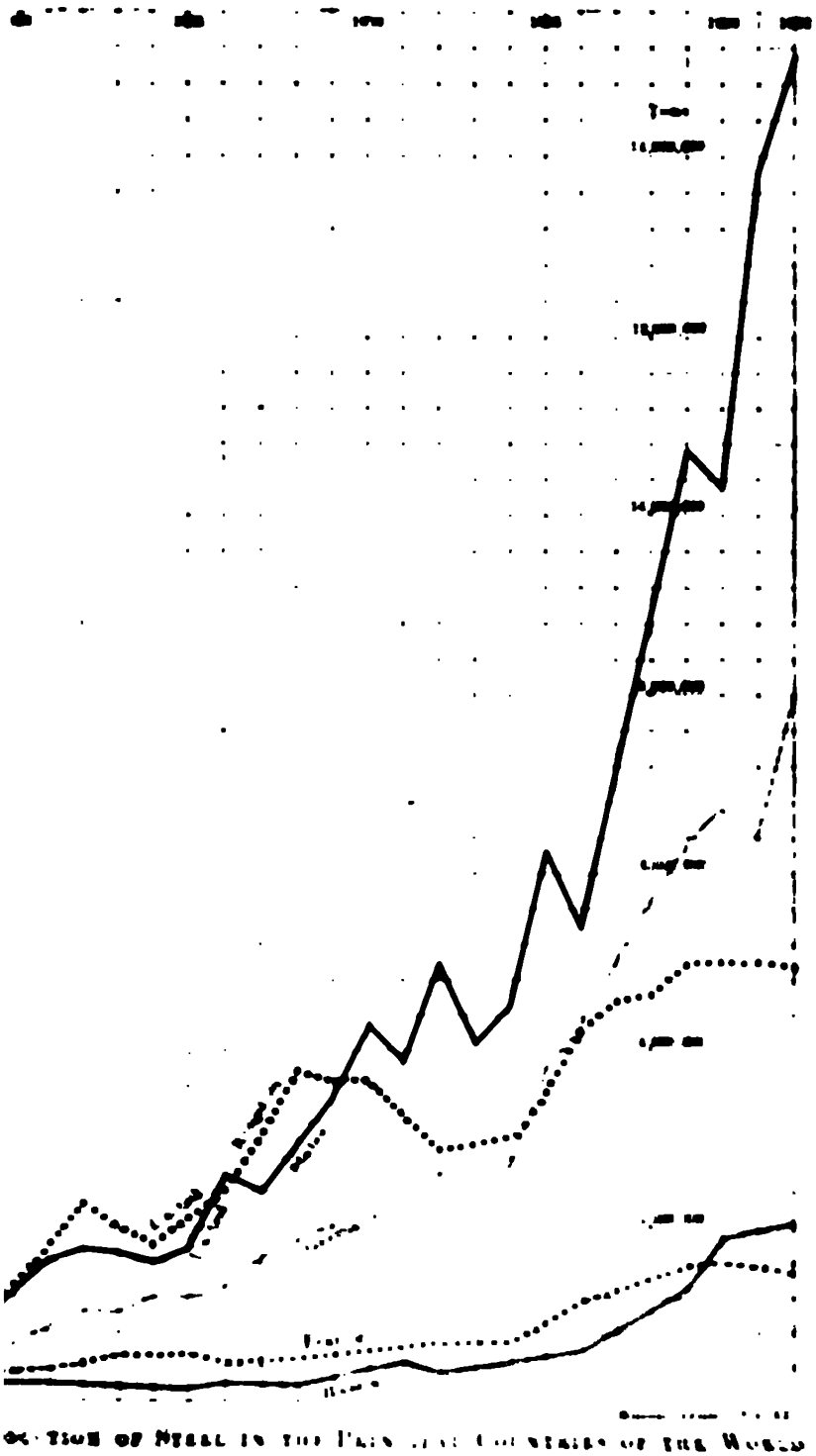
The steel production of the world for five years past is shown in the subjoined table, the figures being given also in metric tons:—

STEEL PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1898	605,700	567,728	22,288	1,174,000	5,734,307	87,467	1,095,000
1899	1,127,104	729,820	22,352	1,940,000	6,390,434	108,501	1,321,295
1900	1,145,654	655,199	23,954	1,565,164	6,645,869	115,897	1,380,000
1901	1,142,500	526,670	26,501	1,426,351	6,394,222	121,300	1,815,087
1902	1,143,900	776,875	184,950	1,936,350	7,780,992	170,350	1,730,250



THE PRODUCTION OF PIG IRON IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.



PRODUCTION OF STEEL IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.

16,500 tons of finished iron. Seven new furnaces are being built in Bosnia; they are of small size and will use charcoal as fuel.

Belgium.—The production of pig iron during 1902 showed a considerable improvement over that of the previous year. The outputs being as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Foundry iron	92,700	108,560	I. 15,860
Forge iron	166,955	256,435	I. 89,480
Steel pig	505,765	737,915	I. 232,150
Totals	765,420	1,102,910	I. 337,490

The average number of furnaces in blast in 1902 was 33, showing an output of 33,422 tons per furnace. Belgium has adhered to the puddling furnace more closely than any other country, except Great Britain. The production of wrought iron in all forms in 1902 was 377,910 metric tons, chiefly in bars, angles and plates. The production of steel ingots was 776,875 metric tons, as compared with 526,670 tons in 1901, showing an increase of 250,275 tons, or nearly 48%. The output of finished steel in 1902 was 755,880 tons. The large increase over 1901 was due mainly to a great improvement in the export trade.

The future of the Belgium iron trade is not altogether clear. Iron ore supplies are already derived largely from abroad, while the cost of coal is increasing, as the upper seams have largely been exhausted and deep mining is necessary. The Belgium industry has prospered largely because the labor supply has been abundant, and wages generally low. Both in coal mining and in the iron trade, however, there has been much discontent recently, and some serious strikes have taken place. It appears that increases in labor cost, as well as in fuel costs are imminent. As the iron industry depends largely upon foreign buying, in which sharp competition must be met, the situation is a serious one. At the same time, Belgium iron-masters are generally alert and progressive, and have shown themselves ready to take every advantage, not only in trade, but also in a technical way. Thus the John Cockerill Co., at Seraing, was a pioneer in the utilization of waste gases from blast furnaces. Its machine shops are now the largest manufacturers of blowing and other engines for the conversion of such gases into power.

Canada.—The iron and steel industry in Canada has advanced rapidly in recent years, chiefly owing to the developments in Nova Scotia. The works at Sault Ste. Marie, from which so much was expected, are not yet in full operation.

The total production of pig iron in 1902 amounted to 319,557 long tons, against 244,976 tons in 1901 and 86,090 tons in 1900. In the first half of 1902 the production was 157,804 tons and in the second half it was 161,753 tons, a gain of only 3,949 tons. Of the total product in 1902, 302,712 tons were made with coke and 16,845 tons with charcoal. A little over one-third of the total product was basic pig iron, namely, 107,315 tons. The Bessemer pig iron made amounted to about 9,000 tons. Spiegeleisen and ferromanganese have not been made since 1899. The total production of steel ingots and castings in Canada in 1902 was 182,037 long tons, as compared with 26,084 tons in 1901, an increase of 155,953 tons. Bessemer and open-hearth steel ingots and castings were made

[illegible] Almost all of the open-hearth steel reported in 1902 was made by [illegible] process.

[illegible] increase in the production of steel in Canada in 1902 over 1901 was [illegible] the starting up of the new open-hearth steel plant of the Dominion [illegible] Co. Ltd., at Sydney, Cape Breton, N. S., which first produced [illegible] Dec. 31, 1901, and of the new Bessemer plant of the Algoma Steel [illegible] at Sault Ste. Marie, Ont., at which steel was first made on Feb. 18. The latter company has two 5-ton Bessemer converters, which were [illegible] for a few months in 1902, producing in all 11,317 long tons of ingots. [illegible] has also a rail mill which first made Bessemer steel rails on May 8, [illegible] also ran for a few months in that year, producing 32,878 long [illegible] this company also produced 1,246 long tons of other rolled [illegible] 1902. The Dominion Iron & Steel Co. produced 99,125 long tons open-hearth steel ingots and castings and 86,124 tons of blooms, billets, [illegible] but it made no steel rails. The Dominion Iron & Steel Co. obtains [illegible] part of its ore supply from its mines at Bell Island, Newfoundland. Its [illegible] coke, made from Cape Breton coal, in by-product ovens.

[illegible]—The iron trade in France was comparatively quiet during 1902, [illegible] recovery was shown from the depression of 1901. The chief [illegible] in demand was in material for new electric installations. Marine [illegible] were quiet during the year, and export trade rather light. [illegible] returns of pig iron, as officially reported, is given in the subjoined

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible] The [illegible] 372,381 [illegible]

The production of steel ingots was as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Bessemer	816,677	1,(14,264	I. 198,287
Open-hearth	608,674	620,366	I. 11,692
Totals	1,425,351	1,635,300	I. 209,949

The official reports do not distinguish between basic and acid steel; but the larger part of the steel is made by the acid process. The production of finished steel is reported as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Bars and merchant steel	614,018	653,931	I. 39,913
Plates	269,908	276,287	I. 6,379
Rails	291,528	301,434	I. 9,906
Totals	1,175,454	1,231,652	I. 56,198

The finished steel produced during 1902 is classified as follows: Converter steel, 682,814; open-hearth, 517,408; puddled steel, 12,041; cemented, 1,005; crucible steel, 12,715; made from scrap and old steel re-worked, 5,670; total, 1,231,652 metric tons.

Little was done during the year in the way of new works. Some additions were made to the forges of St. Etienne. Schneider et Cie. nearly completed the building of a large blast furnace plant at Cette, near Marseilles. It will use chiefly Algerian ores, from Mokta-el-Hadid and Beni-Saf. The location, on the Mediterranean seaboard, is for the purpose of receiving those ores at a low rate. Development work has proceeded steadily on the large body of minette ores discovered two years ago close to the German frontier.

Germany.—The iron trade of Germany in 1902 showed some recovery from the depression, which marked it in 1901, which was due rather to an increased export business than to any improvement in the foreign trade.

The pig iron production, including Luxemburg, as reported by the German Iron & Steel Union, was as follows:—

	1901.		1902.		Changes.
	Metric Tons.	%	Metric Tons.	%	Metric Tons.
Foundry iron	1,512,107	19·4	1,619,275	19·3	I. 107,168
Forge iron	1,356,794	17·4	1,206,550	14·3	D. 150,244
Bessemer pig	464,036	6·0	387,334	4·6	D. 76,702
Thomas (basic) pig	4,452,950	57·2	5,189,501	61·8	I. 736,551
Totals	7,785,887	100·0	8,402,660	100·0	I. 616,773

Spiegeleisen and ferromanganese are included with forge pig, under the old German classification. The total increase in 1902 over the preceding year was 7·9%. The production for 1902 was the largest ever reported in one year, except that for 1900, which was 8,422,842 metric tons.

Imports of pig iron into Germany in 1902 were light, amounting to 143,040 tons, compared with 267,503 tons in 1901; a decrease of 124,463 tons, or 46·4%. *The exports*, on the other hand, showed a large increase, the total for 1902 being

tons, compared with 150,618 tons in 1901, an increase of 196,808 tons, or

Most of this increase was due to a demand from the United States.

other products of all kinds, outside of pig iron, showed a large increase

exports in 1902 being 2,961,761 tons, compared with 2,196,794 tons

an increase of 764,970 tons, or 34·8%.

imports and exports of iron ore for the year were as follows:—

	1901	1902	Changes
	Metric Tons	Metric Tons	Metric Tons
			D
			I
			D

ores were chiefly from Spain and Sweden. The exports were chiefly

ore from Luxemburg, which went to France.

The production in 1902 was as follows:—

	Acid		Basic		Total	
	Metric Tons	£	Metric Tons	£	Metric Tons	£

Phoenix, however, continues to strongly favour the German steel

The great bulk of pig iron and steel was made in the second half

of steel were

The production of pig iron in this country is controlled by a number

made from

The Bessemer steel works

arrangements

An effort

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and girders, 37·2% of the remainder

The iron ore supplies of Russia are exceedingly miscellaneous. Until quite lately the workings were on a very small scale. In 1890, for example, the official returns showed that ores were mined from 536 mines or quarries, and 195 labo[ratories], 180 of the latter being in Finland and 15 in North Russia. The total output of iron ore from these 731 workings was under 1,900,000 tons, so that the average output was only about 2,600 tons. In more recent years, however, attention has been concentrated on the more productive sources of supply, and Krivoi Rog, Blagodat, and other deposits are worked on a scale of some magnitude. Brown iron ore is the staple source of supply, followed in the order of volume by red hematite and magnetic iron ore.

The iron industry of Russia is still carried on under somewhat primitive conditions in most of the leading districts apart from the south. As recently as 1885 there were 195 blast furnaces available, and these produced a total of about 500,000 tons of pig iron, of which all but 10% was produced by charcoal fuel. In the following decade this condition had considerably altered, although charcoal pig iron continued to be the staple. In 1880, about 55% of the blast furnaces in the country were worked with cold blast, but in 1890 the proportion was 32%, and at the present time it is probably not more than 16%.

Spain.—Although Spain is a large producer of iron ore, the metallurgical industry is of only moderate proportions. There was little change in the industry during 1902. The total exports of iron ore in 1902 were 7,546,512 metric tons; this figure compares with 6,637,613 tons in 1901, and 7,823,270 tons in 1900. Approximately 70% of these exports is shipped to Great Britain.

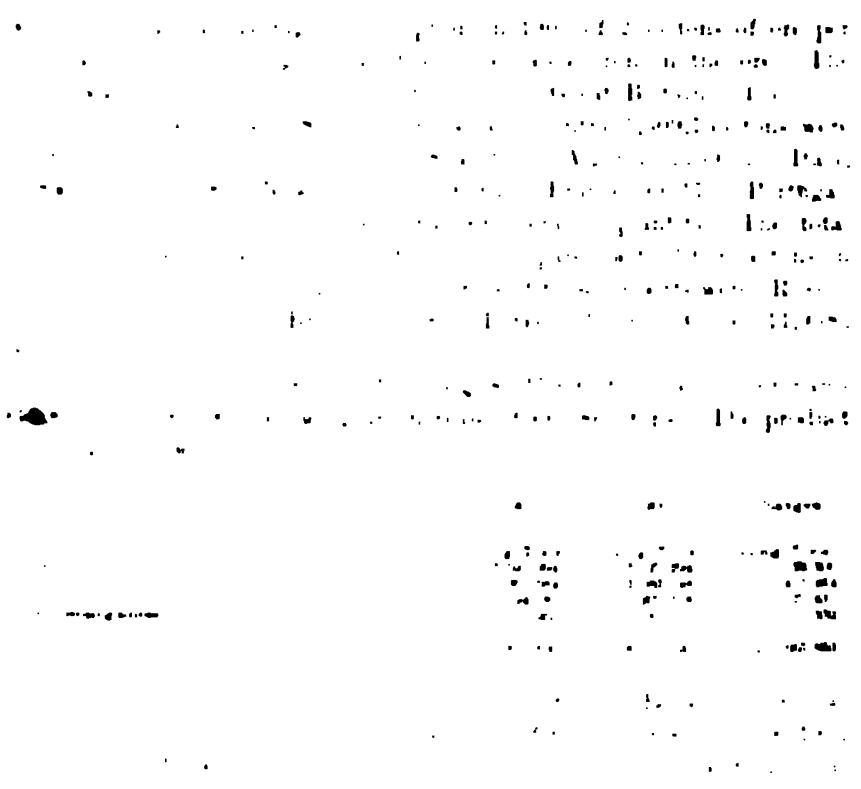
Sweden.—According to Dr. Richard Akerman the output of pig iron in Sweden during 1902 for the year was 524,400 metric tons. All of this iron was made with charcoal as fuel. The quantity of blooms produced from pig iron in charcoal hearths was 183,600 tons. The steel production for the year was 283,500 tons of ingots, of which 193,300 tons were made in open-hearth furnaces, while 85,200 tons were Bessemer or converter steel. The exports of iron and steel for the year included 73,296 tons of pig iron, 20,380 tons of charcoal blooms, 8,148 tons of steel ingots and 174,013 tons of bar iron and steel. The exports of iron ore in 1902 reached a total of 1,719,293 metric tons.

The Swedish iron-masters are turning their attention more and more to the manufacture of steel. Exports of iron blooms and bars have been decreasing, as open-hearth steel has been coming into use for many of the purposes for which Swedish iron was formerly thought to be necessary.

United Kingdom.—The statistics for the iron and steel trade are compiled by the British Iron Trade Association, and are in somewhat different form from those of the United States.

The supply of iron ore for the British furnaces was as follows:—

	1901.	1902.	Change
	Long Tons.	Long Tons.	Long Tons.
Ore mined in Great Britain	12,266,790	13,496,217	I. 1,15[illegible]
Ore imported	5,548,888	6,341,272	I. 79[illegible]
Total	17,815,678	19,767,489	I. 1,95[illegible]



6,023 tons over that of 1901. The production for five years is shown in the subjoined table:—

STEEL PRODUCTION IN GREAT BRITAIN. (IN LONG TONS OF 2,240 LB.)

Variety.	1898.	1899.	1900.	1901.	1902.
Open-hearth	2,906,000	3,080,251	3,158,039	3,280,791	3,083,288
Bessemer	1,759,266	1,825,074	1,745,004	1,608,253	1,825,779
Crucible	100,000	122,000	121,000	119,000	113,000
Total	4,965,266	4,977,325	5,022,054	5,016,044	5,022,067

An analysis of the steel production in 1902, omitting crucible steel, is as follows, the figures being in long tons:—

	Acid.		Basic.		Total.	
	Long Tons.	%	Long Tons.	%	Long Tons.	%
Open-hearth	2,676,508	54·5	406,780	8·3	3,083,288	62·8
Bessemer	1,157,180	23·6	668,599	13·6	1,825,779	37·2
Totals	3,833,688	78·1	1,075,379	21·9	4,909,067	100·00

For the first time in several years the figures show an increase in the proportion of Bessemer steel. The Bessemer, or converter, metal was largely used for rails, of which 903,216 tons were made last year. The open-hearth process is preferred to the converter; and years ago the output of open-hearth steel exceeded that of Bessemer. The number of converters and steel furnaces shows very little change in 1902, the new ones constructed having been mainly to replace older apparatus worn out. Very much the same thing may be said of the blast furnaces—the new blast furnaces mainly replace old ones. They generally show some increase in capacity, but less than in this country, for the British iron-maker has never favored the very large furnaces, such as are found at the later works in this country.

The condition of the British trade in 1902 was very much more satisfactory than in the preceding year. The year 1901 was a period of depression, owing partly to a decrease in the home demand for iron and steel, and still more to the crisis in Russia, Germany and other European countries. The British trade depends largely upon export, and in 1902 there was an important revival in the foreign demand. In part, this was due to improved conditions abroad, and in part also to the fact that the United States, absorbed in its own huge home demand, practically withdrew from foreign markets, while it also purchased a very considerable quantity of British iron. The trade showed greater steadiness, with fewer variations in prices, than for a number of years past. It presented, however, one anomaly, and that is a decline in prices of finished iron and steel, accompanied by an advance in the average selling value of pig. Manufacturers also found prices higher for iron ores and coke, and these were not offset by a small reduction in the rate of wages for labor. The various branches of manufacture in which iron and steel were used were generally prosperous, with the exception of the shipbuilding business, which forms a very important section of the British trade; in this business there was less work than for several years

Notes on Progress in Iron and Steel Metallurgy during 1902.

By Frederick Hobart.

Electric Furnaces.—With regard to the metallurgy of iron and steel, the electric furnace occupies only a modest place in this branch of industry, and it is doubtful whether the manufacture of iron and steel on the same vast scale in the regions where it is now carried on under most favorable conditions could possibly be obtained by the use of the electric furnace.

Reduction of Iron Ores.—Although the reduction of iron ores by electricity has formed the subject of a practical study by Mr. Keller,[4] the results of which will be described further on, it may be stated at once that the use of electricity as a reducing agent is only practicable from an economic point of view, first, when it is a question of manufacturing special qualities of iron from pure ore delivered at the works on favorable terms; secondly, when it is desired to foster an iron and steel industry in a country hitherto undeveloped in this respect, into which all the coal must be imported, where iron ore of good quality abounds, and where natural sources of power are available in the immediate neighborhood of the ore deposits.

General Conditions of the Economic Possibility of the Electric Reduction of Iron Ore.—In a few words, and without going into detail, it will be useful to sketch briefly the relations between the principle of manufacture and the possibility of the reduction of ore by electric methods. The author has determined experimentally that one kilowatt-year utilized in an electric reducing furnace is capable of yielding about four tons of steel-making pig iron. If, therefore, the cost of one kilowatt-year equals K, the expenditure in electric energy per ton of iron smelted will equal $K \div 4$. Adding to this cost of 350 kg. of coke necessary for the reduction of one ton of iron, the expenditure representing the electric energy absorbed and the fuel requisite for reduction will be equal to

$$\underset{\text{(energy)}}{\frac{K}{4}} + \underset{\text{(reduction)}}{350 \text{ kg. coke.}}$$

On the other hand, as is well known, about 1,000 kg. coke are required for the production of one ton of pig iron in the blast furnace, and assuming for the moment that the labor, maintenance and sundry accessory expenses are the same in either case, and that the cost of supplying the blast balances the cost of the electrodes, which is approximately exact; and further, that the price of coke at the electric station is 28s. per ton, while at the iron works it is only 16s., then the cost of production in both cases will be the same on the assumption that

$$\frac{K}{4} + \frac{28\text{s.} \times 350 \text{ kg.}}{1{,}000} = 16\text{s.}$$

which gives a value for K equal to 25s. 6d. In a general way, therefore, the reduction of iron ore by electricity in a country possessing metallurgical works and equally good conditions of transport throughout is only theoretically practicable if the ore can be obtained on equal terms, and if the cost of the kilowatt-year does *not exceed* 25s. 6d. It is true that this latter condition is capable of realization

[4] Paper read at the June (1908) meeting of the Iron and Steel Institute, London.

undertake an industrial tour in Europe, has kindly furnished the particulars relating to the conditions in Chile, which in many points resemble those obtaining in Brazil. Here, too, no iron industry has ever been established, but an abundance of rich iron ore and numerous waterfalls exist, one of which has already been surveyed, and it is estimated that the cost of a kilowatt-year will not exceed $6. The price of English coke delivered in these districts is $20 per ton. Then applying the equation previously given, assuming that coke blast furnaces were in existence in Chile,

$$100 = \frac{K}{1} + 35,$$

or,

$$K = \$52.$$

From this it is clear that coke blast furnaces can never be established in Chile while, on the other hand, there is every likelihood that in the near future electric furnaces will be installed. New Zealand also, with its excellent magnetic ores, which form the sand of the shore, and with considerable waterfalls occurring near the sea in the course of the rivers flowing down from Mount Egmont, affords a good field for the electrometallurgy of iron.

Steel Obtained from the Reduction of Iron Ores.—The manufacture of steel direct from the ores is subject to the same economic conditions which govern the operation of smelting pig iron. The possibility of obtaining superior qualities by means of the electric fining process nevertheless affects the economic aspect of the question. The cost of the electric energy, the basis of the whole process, no longer forms the principal factor in the cost of production. About 1·10 kilowatt-years are necessary for melting and fining of one ton of steel; and even if the motive power is supplied by a steam engine, the expenditure of electric energy will approximately amount to 32s. per ton of steel. This outlay, resulting under the least favorable conditions of generating power, can scarcely form an obstacle to the fining of steel of superior quality by the electric method.

After thus elucidating the general conditions under which the electrometallurgy of iron and steel appears possible, it may be permitted to describe the following experiments undertaken by Mr. Keller several years ago. The manufacture of iron and steel was divided into two quite distinct phases, the reduction and the melting of the raw metal being effected in a primary furnace working continuously, and the fining of the metal being carried out in a secondary furnace working intermittently. The latter was placed at a lower level than the former, and received the metal direct as it was run off from the primary reducing furnace.

The conditions essential to ensure efficiency in the working of the furnace are, first, sufficient power available for treating a considerable mass. Secondly, continuity in working. To comply with these conditions the author adopted the plan of focusing the heat at several points encircling the mass of raw materials. By Mr. Keller's arrangement the use of an acid or a basic lined wall is optional. The furnace hearth is constructed in the same manner as an open-hearth furnace. The melting chamber of the furnace is surmounted by a shaft of brickwork containing the ores, fuel, and fluxing materials, which are charged in from the top

The top of the fining furnace is closed in by a reverberatory crown, and openings are provided for the introduction of the additions and for taking samples. The operations could be facilitated by mounting the furnace upon trunnions and tipping it like a Bessemer converter.

The temperature is easily controlled during fining by the adjustment of the electrodes. It can be increased to a point far above the temperature of the open hearth furnace converter, or crucible furnace, and it is even possible to obtain a heat sufficient to volatilize the iron. By the process of electric fining, reactions can, therefore, be produced which are impossible in the open-hearth. The decarburization should be effected preferably with the aid of metallic oxides, in particular with iron oxide. If a blast is employed a rapid waste of the electrodes ensues; further, the oxygen of the air-blast, after burning the greater portion of the more oxidizable elements, of which carbon is the chief, then reacts upon the iron, forming particles of iron oxide, which, being disseminated throughout the mass, rapidly change its quality. On the other hand, the oxygen of the iron oxide, being in stable combination, is only freed by the energetic reducing action of the carbon. The ore process, therefore, appears to be that which is best applicable to the electric open-hearth. The dephosphorization and desulphurization of the metal bath are also facilitated by the character of the source of heat. The elimination of sulphur can be effected without difficulty owing to the ease with which a reducing action is promoted.

The final additions are made, as in the ordinary process. The only point to be noticed in regard to these is the economy which can be effected in the case of rare metals by the prevention of loss due to their oxidation while making the additions.

NEW BLAST FURNACES.—The following is a list of new blast furnaces begun in 1902, which are expected to be put into blast during 1903:—

One of the two furnaces of the Buffalo & Susquehanna Iron Co., at Buffalo, N. Y.; Wharton Furnace No. 3 at Wharton, N. J.; Palmerton Furnace of the New Jersey Zinc Co., building at Palmerton, Pa., to make spiegeleisen; the furnace of the Rochester & Pittsburg Coal & Iron Co., at Falls Creek, near Du Bois, Pa.; two furnaces of the Sharon Steel Co., at South Sharon; two furnaces at Donora, Pa., of the Union Steel Co.; the third stack of the St. Clair Furnace Co., at Clairton, Pa.; No. 2 Furnace of the Low Moor Iron Co., at Low Moor, Va.; Tuscaloosa Furnace of the Central Iron & Coke Co., at Tuscaloosa, Ala.; Gadsden Furnace of the Alabama Consolidated Coal & Iron Co., at Gadsden, Ala.; the first of a series of furnaces which the Alabama Steel & Wire Co. is to build at Gadsden, Ala.; the new furnace of the Cleveland Furnace Co., at Cleveland, Ohio; the new furnace of the South Chicago Furnace Co., at South Chicago; the Zug Island Furnace of the Detroit Iron & Steel Co., at Detroit, Mich., and the furnace of the Lookout Mountain Iron Co.

During the year 1904 there will be completed the following stacks on which work is now progressing:—

The second furnace of the Buffalo & Susquehanna Iron Co., at Buffalo, N. Y. Nos. 3, 4 and 5 furnaces of the Lackawanna Steel Co.; the fourth furnace at the Ohio Works of the Carnegie Steel Co., at Youngstown, Ohio; No. 3 Furnace

[illegible], Pa., of the Carnegie Steel Co., No. 3 Edna Furnace of the Jones & [illegible] Steel Co., at Pittsburg, Pa., No. 4 Furnace of the National Tube Co., [illegible]port, Pa., the new Franklin Furnace of the Cambria Steel Co., of [illegible]n, Pa., the two new furnaces at Lorain, Ohio, for the Lorain plant of [illegible] Co., the two new stacks of the Cherry Valley Iron Co., at West [illegible] at Lorraine, Ohio, the second furnace of the La Belle Iron Works, [illegible] Ohio, the new Ensley Furnace of the Tennessee Coal, Iron & [illegible] Co., at Ensley, Ala., and Furnace F of the Colorado Fuel & Iron Co., at [illegible]. The addition of these new plants will more than compensate for [illegible] old works incapable of producing iron economically.

Blast Furnace as a Power Plant.—Mr. Edward A. Uehling[1] sums [illegible] of the utilization of blast furnace gases as follows:—

"The application of blast furnace gas to internal combustion engines, [illegible] to recent date, its practicability has already been demonstrated [illegible]. A large number of such engines, varying from 50 to [illegible] the majority over 200 H.P., are to-day in successful operation in [illegible] being far in the lead.

"In a large number of tests it has been found that from 20 to 30% of [illegible] contained in the gas can be realized in effective power. It has been found that 1 lb. of blast furnace gas generates from 1 to 1.5 B.T.U. Now since [illegible] are equivalent to one horse power and taking the average efficiency [illegible] furnace gas engine at [illegible] we find that from 12.5 to 25 lb. of gas [illegible] one horse power hour. In figuring from the total weight consumed [illegible] and dividing by the weight per H.P. hour, the horse power [illegible]

[illegible]

[illegible]

[

the same weight of coke charged into the blast furnace even after deducting the gas required to heat the blast.

"When the fact is considered that it is quite the exception to depend upon blast furnace plants for any surplus power, that on the contrary in the majority of plants thousands of tons of coal are fired under the boilers to assist the gas in producing the necessary steam for the wasteful blowing engines and pumps in a still more wasteful boiler plant, and compare this with the actual power possibilities of the blast furnace it is somewhat surprising that so little has been done in this direction in America.

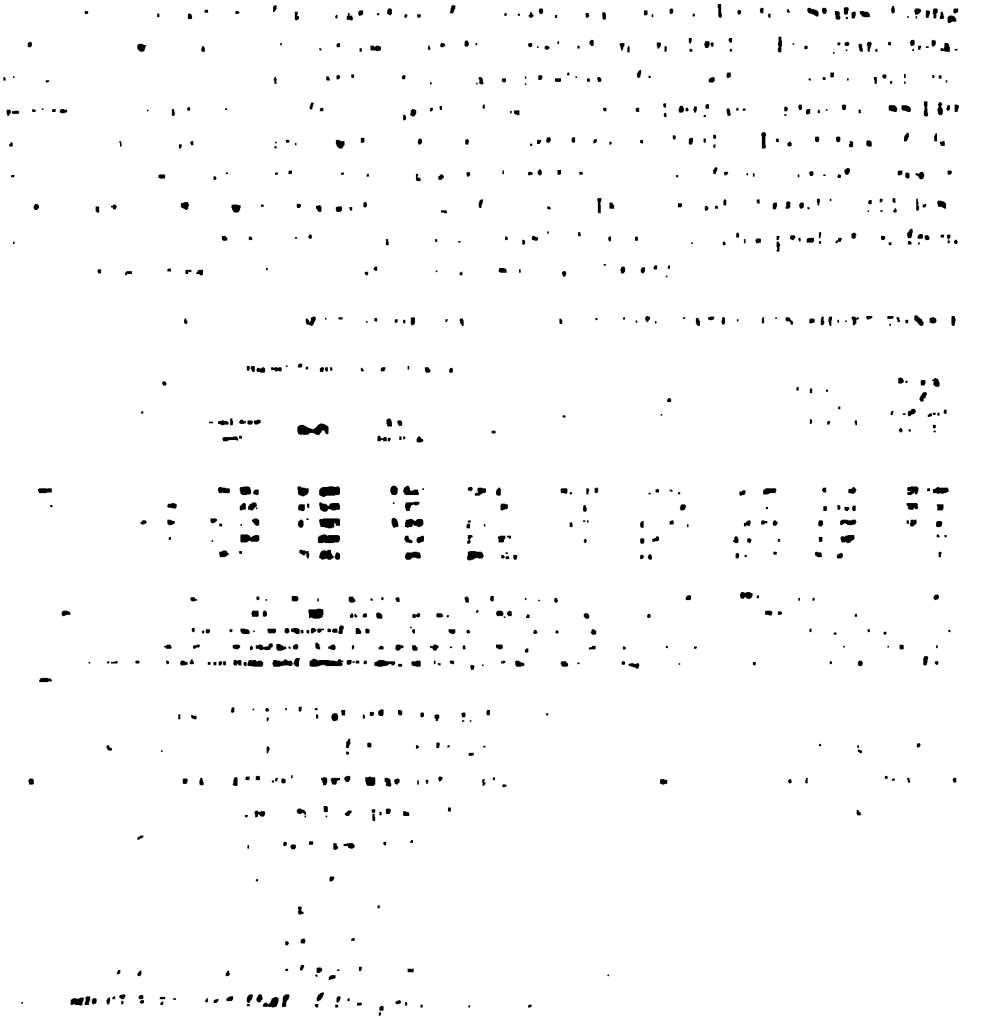
"The path of economy does not lie in the direction of compounding steam cylinders, or increasing the heating surface of the steam boiler plant. Money thus spent, unless it be for temporary purposes, is more or less completely wasted.

"A modern blast furnace plant should not only have no fuel expense for its own power requirement, but should have a surplus of power of at least 800 H.P. for every ton produced per hour for sale which in the majority of localities could be made the source of a handsome revenue.

"To realize this condition, the first and most imperative step is to wash the gas thoroughly, the second is to replace the steam engines by internal combustion engines. A good beginning to utilize the power stored in blast furnace gas, as herewith demonstrated, is being made by the Lackawanna Steel Co., at its new works near Buffalo, where blast furnace gas engines aggregating 40,000 H.P. are now being installed."

LEAD.

By Joseph Wyatt Turner, D. H. Newland and Henry Fisher



Colorado.—The production of lead in Colorado during 1902 was 53,152 short tons, valued at $4,325,484, as compared with 74,056 short tons, valued at $6,419,131 in 1901. The production by principal counties for the two years, as reported by the Hon. Harry A. Lee, is given in the subjoined table:—

County.	1901.		1902.		County.	1901.		1902.	
	Short Tons.	Value.	Short Tons.	Value.		Short Tons.	Value	Short Tons.	Value.
Clear Creek.....	1,945	$168,601	1,641	$138,556	Pitkin	16,875	$1,419,364	12,487	$1,016,128
Hinsdale.....	3,705	328,893	3,107	252,838	San Juan.....	7,786	670,607	3,650	313,393
Lake.....	28,180	2,442,629	19,725	1,605,228	Others.....	6,813	600,515	5,565	482,881
Mineral.....	5,260	455,932	4,646	378,065					
Ouray.....	3,952	342,590	2,131	173,423	Total.....	74,056	$6,419,131	53,152	$4,325,484

The value of the production of the smelters and mills of the Leadville district during the calendar year 1902 amounted to $9,468,544, divided as follows: gold, $1,302,680; silver, $3,051,195; lead, $1,694,410; copper, $303,409; spelter, $3,103,448; and manganese, $8,400. The quantities of ore produced were: oxidized iron ores, 285,494 tons; sulphides, 281,558 tons; zinc ore, 85,699 tons; siliceous ores, 72,215 tons; carbonate ores, 22,730 tons. The American Smelting & Refining Co. reports a production of 50,484 short tons of lead from Colorado ores. The Yak Tunnel has been sunk to a depth of 1,400 ft., and at the 1,300-ft. level, a new ore body was found. An arrangement has been made with the Ibex Co. by means of which the Yak Tunnel proposes to drain the Ibex property, and to prospect it at this level. The independent smelting plant of the Ohio & Colorado Smelting & Refining Co., at Salida, has been completed, and is reported to be smelting from 600 to 700 tons of ore daily, yielding about 30 tons of lead bullion; a roasting plant has been added to the equipment. The Midas mine was a steady producer. No ore was shipped from the Greenback mine for several months during the latter part of 1902, owing to the failure of the owners and the smelter combination to arrive at a satisfactory agreement; the mine is prepared, however, to ship from 300 to 400 tons of ore a day. The Small Hopes mines have been operated upon lease, and in addition to the shipment of a large quantity of ore, development work has been actively carried on.

The bulk of the ores produced in the Leadville district is in the form of fluxing iron ores, which renders the miner dependent upon the rates allowed by the smelter consolidation. The Philadelphia smelter at Pueblo has been closed, due in part to a diminution of Colorado ores and in part to the cessation of shipments of Utah ores, which have been diverted to the new smelting plant at Murray, near Salt Lake City. The utilization of low grade silver-bearing zinc ores promises to be an important factor in the future of the State, and two small concentrating plants have started to work near Denver, and the American Smelting & Refining Co. has installed a small zinc plant at Pueblo, which if successful will be followed by the erection of similar plants elsewhere, so as to act as feeders to the central smelters under the control of the company.

The successful operation of the mills of the A. Y. & Minnie, the A. M. W. and other mining companies, has done much toward the solution of the treatment of the low grade zinc-lead sulphide ores of the Leadville district. A large mill b

reduction in rates and the American Smelting & Refining Co. agreeing to take 12,000 tons of ore and concentrates per month.

The discovery of a 22-ft. vein of silver-lead ore was reported at the Idaho-Centennial mine early in 1902. The company operating this property proposed to install an air compressor and a concentrating plant for the low grade ore, and to ship the high grade ore to the smelter at Everett, Wash. At the Riverview mine at Bayshore, Custer County, a body of high-grade silver-lead ore, 40 ft. wide, has been struck. An incline has been sunk 110 ft. which shows high values along its entire length. This mine was formerly a large producer, but had not been operated for several years, and its reopening in 1902 was due to the approach of the New Salmon River Branch Railway of the Oregon Short Line Railroad. Another mine which has been opened on account of the extension of the railroad is that of the Portland Mining Co. in Shoshone County. This mine has been closed since 1893. The Oregon Railroad & Navigation Co. has completed a branch line from Kingston to Delta, a distance of 33 miles. The company owns the Silver Tip, Sitting Bull and Tuscumbia lead and silver properties near Delta. In the Thunder Mountain district, Idaho County, the Hidden Treasure Mining Co. has acquired the Hidden Treasure and Belle of Thunder Mountain claims.

Iowa.—There was a material falling off in the production of lead ores in this State during 1902. The output amounted to 247,900 lb., valued at $5,761, as compared with 600,000 lb., valued at $13,800 in 1901. All of the lead ores produced were smelted by Wm. G. Watters of Dubuque, who treats as well ores from other States. The total output of lead in the State from all sources amounted to 1,061,000 lb., valued at $42,440, as compared with 1,500,000 lb., valued at $49,000 in 1901. The demand for lead ruled firm, but that for zinc was indifferent, as none was offered. There has been considerable development work on lead properties, and the outlook is quite promising for an increased production during 1903. The average yield of the lead ores treated amounted to approximately 70% lead.

Kansas.—According to the report of State Labor Commissioner Lee Johnson, the formation of a purchasing company to handle the entire output of lead and zinc ores from Kansas was contemplated. This company was to receive the production from the various mines, and to sell it to the smelters, the purpose being to maintain a uniform price, and if necessary to sell any surplus production outside the State, but on the advance of the price of ore, the plans were not put into effect. The average monthly price of lead ore was $21 in January, which rose to $21·75 in February, fell to $20·75 in May and rose to $25·75 in December, making the average for the year $23·11. The only change in the mining practice in 1902 was the use of buckets of 1,000-lb. capacity instead of 500-lb., and of heavier cables and hoisting engines. Very few mills were built, but many were moved to new localities, most of them to the southwestern Missouri district. The use of the Wilfley table has also become more general. There are 192 mills in the State with a crushing capacity of 19,350 tons daily. The entire output of lead and zinc in ores during 1902 was 78,518,600 lb., valued at $1,216,431, as compared with an output valued at $1,413,948 in 1901.

machinery and equipment has been shipped to other plants of the company. At the plant at East Helena, labor troubles caused a shut-down during May, June and a part of July, which reduced the tonnage of ore smelted during the calendar year to 11,000 tons monthly. The bag houses erected to collect the dust from the blast furnace gases, did not prove a success owing to the character of the ores treated, as the gases produced during the smelting destroyed the bags too rapidly. This system was replaced with a long steel flue which cools the gases and facilitates the deposition of the material held in mechanical suspension and aids, as well, the condensation of the metallic values contained in the gases in a volatilized condition.

Nevada.—The Rocco-Homestake mine of White Pine County, in 1902 produced ore to the value of $46,925. Of the gross earnings of the company $12,236 were expended for labor, $6,545 for freight between the mines and railway terminus, and $19,511 for freight between railway terminus and Salt Lake, the smelting center. It is estimated that 5,000 tons of ore have been developed on the property, which will average 70·1% Pb and 21·4 oz. silver per ton.

New Mexico.—Three smelting plants were in operation during the year at Cerillos, Magdalena and Silver City, and the construction of the pyritic smelter at Lordsburg was completed. A large portion of the ores produced in this State is treated at the El Paso smelter in Texas. The chief producers of lead ores were the mines in the Magdalena Mountains and at Cooks Peak.

Tennessee.—According to the report of R. A. Shiflett, Chief Mine Inspector, the quantity of lead contained in the lead ores produced in this State during 1902 amounted to 500 short tons, valued at $2,000. There were 18 men employed in this industry throughout the year.

Texas.—In July, 1901, the silver-lead smelting plant at El Paso, was destroyed by fire, and April 15, 1902, the furnaces of the new works were blown in. There are seven lead blast furnaces rated at from 200 to 250 tons charge per day, and three copper blast furnaces, each with a daily capacity of from 250 to 300 tons. The furnaces are fed from a 6-ton charge car, which is moved along the ore, flux and fuel bins by means of an electric motor, and, after having received its charge, is raised 38 ft. by a 15-ton hydraulic elevator to the top of the furnaces, where it travels over them to the charging openings. As the copper furnaces are lower than the lead furnaces, the charges for them are first dropped into hoppers from which they are discharged into the furnaces. Crude Beaumont (Texas) oil is used in the roasting and boiler departments. The power plant is equipped with seven boilers, representing a total of 1,250 H.P., and four blowers of a capacity of 30,000 cu. ft. per minute direct connected to three tandem compound condensing Corliss engines. The sampling works, briquetting machinery, pumps, hoists, motor cars, etc., receive power from a central electric plant.

Utah.—The production of lead by counties, as reported by B. H. Tatum, United States Assay Office, Helena, Mont., is given on the following page.

The blast furnace of the new smelting plant of the American Smelting & Refining Co. at Murray, nine miles south of Salt Lake City, was blown in during the early part of the summer of 1902. The works are built on a horizontal plane. There are, however, two drops, one of a few feet from furnace house floor to the

d to furnish the room necessary for the matte settling boxes, and the ...ne entire slag yard to furnish dumping ground for the slag. The ...ow discusses the crushing and roasting department, the smelting

...

...

...

Separate from the three main divisions are the sampling and flue dust briquetting mills.

The new smelting plant of the United States Mining Co., at Bingham Junction, was put in commission in October, 1902. At first, mechanical charging of the furnaces was adopted which, however, did not meet with success, and a return was made to the common practice of charging by hand. The capacity of the plant is 1,000 tons of ore per day, and ores are purchased in order to mix advantageously with the ores of the United States mine at Bingham and the Centennial-Eureka mine at Tintic, both owned by the company. The entire holdings and rights of the Utah Consolidated Gold Mining Co., of England, operating the Highland Boy mine and smelter at Bingham, have been transferred to the Utah Consolidated Mining Co., of New Jersey. The Uncle Sam Consolidated Mining Co. owning the Uncle Sam and Humbug mines at the north end of the Tintic range in Juab County, is shipping about 300 tons of ore per month, the ore being mainly silver-lead. The Uncle Sam ore carries about 1 oz. silver to every 20 lb. of lead, and the Humbug ore about 1 oz. silver to every 10 lb. of lead. The gangue is quartz and lime. The ore also carries from $1 to $10 in gold. A 50-ton concentrating mill is to be erected. The Gilmore Mining Co. of Texas district, in Idaho, is developing its property. It has 700 ft. of tunnel in cross-cutting and drifting on its various shoots of ore. It is shipping ore every two weeks, and will ship concentrates also from its jigging plant, which has already been erected. A ton of concentrates is obtained from 3 tons of crude material, the concentrates assaying 65% lead and about 40 oz. silver. The capacity of the jigs is 14 tons of ore daily. Hoisting works and ventilating tubes are to be installed.

LEAD PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Australasia. (*c*)	Austria.	Belgium.	Canada.	Chile. (*d*)	France.	Germany.	Greece.	Hungary.
1897	.....	9,680	17,023	17,698	370	9,916	118,881	16,486	2,397
1898	67,000	10,340	19,330	14,477	13	10,920	132,742	19,198	2,305
1899	87,600	9,736	15,700	9,917	171	15,981	139,295	19,059	2,166
1900	87,100	10,650	16,365	28,654	14	15,210	121,513	16,395	2,020
1901	90,000	10,161	18,760	28,542	455	21,000	123,098	17,644	2,029

Year.	Italy.	Japan.	Mexico.	Russia.	Spain.	Sweden.	United Kingdom. (*b*)		United States.	Totals.
							Foreign Ores.	Domestic Ores.		
1897	22,407	1,737	71,637	450	189,216	1,480	13,312	26,966	179,369	669,105
1898	24,543	1,705	71,442	241	198,392	1,559	23,239	25,761	207,271	776,615
1899	20,543	1,969	84,656	322	184,007	1,606	17,571	23,929	196,918	680,933
1900	23,763	1,877	63,827	221	176,600	1,424	10,736	24,762	253,204	654,697
1901	25,796	1,806	94,194	250	169,294	988	19,689	20,961	253,944	692,955

(*a*) The statistics for Austria, Belgium, Canada, France, Germany, Hungary, Italy, Japan, Russia, Spain and Sweden are from the official reports of the respective governments except where otherwise noted. Those for Greece are based on the authorities given under the general table of mineral production of Greece in a subsequent part of this volume. Those for the United States are from data collected by THE MINERAL INDUSTRY. Those for the United Kingdom as specified in note *b*.

(*b*) The production of lead in the United Kingdom is given in two columns. One gives the amount of lead derived from domestic ores, the yield of which is calculated at 95%, as reported in the official British blue books. The other column gives the production of lead in the United Kingdom from foreign ores smelted there. These figures, which are not reported in the official blue books, are obtained by deducting the production of British lead from the total output of the lead smelters of the United Kingdom as stated in the *Statistische Zusammenstellungen über Blei, Kupfer, Zink und Zinn* of the Metallurgischegesellschaft, Frankfort-on-the-Main.

(*c*) From the *Statistische Zusammenstellungen* of the Metallurgischegesellschaft, Frankfort-on-the-Main. These figures comprise only the lead exported to Europe and America. (*d*) Exports.

waste products, as a result a degree of success was achieved in solving the
problems. The Broken Hill Proprietary Co., Ltd., during the fiscal year
Nov. 30, 1902, treated 263,659 tons of ore yielding 64,676 tons soft
427 tons antimonial lead, 5,477,143 oz. silver and 2,935 oz. gold. Of the 6
tons of ore raised, 85,235 tons were obtained from open-cut, and 558,35
from underground workings. The gross profits for the year amounted to £1
which, after deducting £42,364 for depreciation of various plants, yielded
profit of £102,697. For construction the sum of £32,424 was expended, a
dividends of £48,000 each were paid. The balance at the end of the fisc
was £550,091. Experiments with the "Huntington-Heberlein" process
been satisfactory, a plant to carry on this process, which consists in deli
the roasted concentrates in a lumpy condition to the furnaces instead
briquetting them, has been completed, and it is believed that this will ma
strengthen the earning power of the company by increasing the recovery
metallic content of the ore. The results obtained with the magnetic conce
have not been sufficiently satisfactory to justify the erection of a working
Eight furnaces are in operation at Port Pirie, one of which has been convert
a circular furnace, and is under trial. During the fiscal year 243,655 tons
concentrates, etc., were smelted, with an average yield during the first ha
of 18·81% Pb and 18·71 oz. silver per ton, and during the second half-
21·71% Pb and 19·69 oz. silver per ton. The refinery treated 47,721 t
silver-lead bullion, yielding 4,644,366 oz. fine silver, 2,935 oz. fine gold,
tons soft lead and 427 tons antimonial lead. In addition to the ore sme
Port Pirie, a quantity of concentrates was sold, the total output amount
64,676 tons lead and 5,349,426 oz, silver. The Broken Hill Proprietary
10 Co., Ltd., for the year ending Sept. 30, 1902, treated 85,672 tons
ore yielding 15,968 tons concentrates containing 10,297 tons lead and 545,
silver. The expenditures during the half-year ending Sept. 30,
amounted to £46,387, the income to £46,494, the net profit to £1,284; the
and loss account was increased to £17,810. There were 46,401 tons lead o
403,836 tons zinc ore on hand at the end of the fiscal year. Magnetic sep
is being tried on the ore, but the results are still unsatisfactory. A new
plant is being erected and a new mill will be built in January, 1903.
concentrating plant several alterations have been made, greatly increas
efficiency.

The Sulphide Corporation, Ltd., during the fiscal year ending June 30
milled 251,056 tons of ore, assaying 18% lead, 19·5% zinc and 11·8 oz.
which yielded 50,753 tons of lead concentrates containing 45,444 tons lead,
tons zinc and 2,964,263 oz. silver. In addition 463 tons of concentrates we
duced by re-treatment of 2,627 tons of slimes from the old dump. The m
separation plant, which was completed in October, 1901, can handle 3,0
of middlings per month. During the year 11,372 tons of these middlin
treated, yielding 5,336 tons of concentrates containing 2,094 tons zinc, 7
lead, and 74,204 oz. silver. The results are so satisfactory that a plant
erected to increase the output of zinc concentrates. It will be used t

products imported into Canada, was framed before the lead industry exi and provides for a duty of 15% on pig and 5% on corroded lead, less in each stance one-third, if the import is of British origin. Such duties are not ficiently protective to be of use to the British Columbia miners, who, driven a return to normal prices for lead, are compelled either to go out of business seek such changes in the tariff as will result not only in giving the miner a hig average price for his lead, but will tend as well to the establishment of corrod works within the Dominion. In seeking an increase of duty rather than other form of assistance, the miner is looking forward to the results of the gr industrial expansion which is taking place and to the consequent increase of home consumption, of which he rightly thinks, he should have some of the be fits, as against the interests of the Mexican who now supplies most of the Ca dian lead trade through American channels.

During 1902 more than 80% of the lead ores and 75% of the lead content them was smelted, either at Trail or Nelson. Without these local smelters, t mining of much of the very low-grade Rossland ore, (which is used as dry o by the Trail plant) and of practically all of the dry silver ore output of the Pro ince, would be impossible. The dry-ore miner should therefore take an acti interest in the affairs of the lead miner. Shortage of coke supplies, due to strik at the coal mines, and shortage of lead ores, because of low prices, necessarily rendered lead smelting operations very unsatisfactory, each plant running only one furnace during most of the year. Electrolytic refining of lead (which is described under the caption "Recent Improvements in Lead Smelting," given later in this section), was successfully established at the experimental plant of the Canadian Smelting Works, at Trail, from which during the second half of the year, 876 short tons of lead were produced and sold in Canada.

Chile.—The export of silver-lead from Chile during 1901 amounted to 441 metric tons valued at $197,396 (Chilean currency).

France.—The production of lead ore during 1901 amounted to 20,650 metric tons, chiefly derived from the Pontpéan mine in Ille-et-Vilaine, which contributed 11,000 tons of silver-lead ore and 4,600 tons of zinc blende. Other silver-lead mines are in the departments of Hautes-Pyrénées, Aveyron, Tarn, Ariège and Drôme.

Germany.—The production of lead ore in Germany in 1902 was 167,855 metric tons ($3,359,000), as compared with 153,341 metric tons ($3,535,250) in 1901. The output of lead was 140,331 metric tons ($7,837,250) and litharge 4,197 metric tons ($258,250), as compared with 123,098 metric tons ($8,058,250) and 4,101 metric tons ($282,000) respectively in 1901. In 1902, the output of the Verein fuer die Berg-und Huettenmaennischen Interessen in Aachener Bezirk was 32,938 tons of lead ore and 60,486 tons of pig lead. The average price obtained for the lead was $5·57 per 100 kg. During 1902 the output of lead ore in Silesia amounted to 52,757 metric tons, valued at $971,327, and of lead, 30,240 metric tons ($1,709,862), and of litharge 2,119 metric tons ($122,623). The production of lead ore in the Bonn district during 1902 was 63,703 metric tons.

Italy.—The ore deposits in the Iglesias district, Sardinia, occur either as veins or as caverns and beds, the former being found exclusively in schists and the latter

...ne. In general, the veins strike N.E.-S.W., and dip toward the north; ... an width up to 5 ft. and even greater, and are filled with argentiferous ...ende and calamine. The galena is rich in silver as compared with the ... bedded deposits, and the silver sulphide present appears to occur also ...gene which is chiefly quartz and calcite, although fluorite and barite ...ccurred. The most important vein deposits are at Montevecchio and ... Ingurtosu, others are at San Giovanni, Su Zurfuru, Marganai, Nebida, San Benedetto, Malacalzetta and Montenuovo. The cavern and bedded deposits consist chiefly galena and calamine with occasional cerussite and blende, ...ome calamine alone occurs, while at Montejani, galena poor in silver ...lone. The cavern and bedded deposits occur almost always near the ...ower limestone and Silurian schists, and ores of this class are worked ...om San Benedetto, Nebida, Seddas Moddizzis, Marganai and Malacalzetta, the first and last named rank among the most important mines. The production of lead ore in the Iglesias district during 1899 was ... as compared with 11,151 tons in 1898, and of zinc ore 127,214 tons as compared with 111,585 tons in 1898. There were produced, also, ... tons of silver, antimony, manganese and iron ores, and about 25,000 ... per annum. The number of workers in the lead and zinc mines in ... was ... A small quantity of lead ore is smelted on the Island, 1,917 ... of matte having been exported in 1899, but by far the greater part of ... is sent to the mainland of Italy for reduction. A little zinc ore ...s smelted at home, but the greater part is treated at Belgium and France, ... having been sent to the former, and 2[illegible] tons to the latter in 1899.

Mr. James W. Malcolmson ... [illegible] under the system devised by ... [illegible] ... The [illegible] ... mining in Mexico is largely [illegible] ... exports [illegible] ... of Pb. S ... are to [illegible] ... Besides Mexican lead ores in the country, ... [illegible] ... have been built up in connection [illegible] ... and the ... [illegible] ... Fully [illegible] ... of all the ores mined in the country ... [illegible] ... steps were taken to reopen the numerous lead mines of ... Smelting & Refining Co., which had been closed on account of ... [illegible] ... and the destruction [illegible] ... Plant, smelting works [illegible] ... Smelting & Refining Co. [illegible] ... the Guggenheim Explora... were ... controlling [illegible] ... of Santa Barbara, Parral, ... Maria Valdecañas, and [illegible] ... and several [illegible] ... properties [illegible] ... The Compañia Metalurgica and its allied organizations, the Mexican Lead Co. and Monte... [illegible] ... produce the same [illegible] ... [illegible] ... in the States of ... Nuevo Mejico, Santa Barbara, Monterey, San Pedro, Chihuahua ... other points. The new [illegible] ... of the Compañia Metalurgica Mexicana, which commenced [illegible] ... near the Valadeñas lead ... and the American [illegible] ... Torreon, [illegible] ... The plant ... smelting [illegible] ... per month, made a profit of $[illegible] ... a capitalization of $[illegible]

... *La Santa Eulalia* ... near Chihuahua City, American capitalists

took over the Potosi mine at the end of 1901, and have opened it up through the adjoining Santo Domingo property, at a depth of 1,300 ft., with extraordinary success. The Santo Domingo and Potosi silver-lead ore bodies are larger than any developed lead carbonate deposits in Leadville, but the silver assays are lower. The adjoining mines of the Hearst Estate and the American Smelting & Refining Co. also contain very large quantities of carbonate ore. Two narrow gauge railroads are at present unable to handle the output of lead ores from this camp. Discoveries of lead carbonate ores at Terrazas, 40 miles north of Chihuahua City seem to be important. Along the Conchos River, low grade silver-lead ore deposits are being reached by the Kansas City, Mexico and Orient Railroad, which will probably be available during 1903. At Santa Barbara the Guggenheim Exploration Co. has opened up in the Tecolotes mine an ore body carrying silver-lead sulphides. The crushed ore is screened, classified and passed over Wilfley tables, saving 90% of the lead. Gas producers are successfully used in the power plant. The Montezuma Lead Co., operating in the same camp has built a large concentrator using jigs. At Naica, near Santa Rosalia, high grade basic silver-lead ores have been mined in large quantity. An enormous ore body was found in the San Pablo mine of the Mexican Lead Co., but a serious fall interfered with operations. The mine is now in running order again. The production from the Axtec and Carbonate mines of the Monterey Smelting & Refining Co. is only limited by the necessities of that plant. During 1902 the Zaragoza silver-lead mine has been acquired and operated by the Guggenheim Exploration Co.

Coahuila.—Operations in the Sierra Mojada mines which usually produce very large quantities of silver-lead carbonates were very much reduced on account of the fire at the El Paso smelting works. The properties are now being reopened and more than 10,000 tons of ore are being shipped per month. The fire in San Salvador mine burned throughout the year. This mine contains considerable native sulphur, and over 30,000,000 ft. of lumber in square sets. There is no water available. The blowing in of the Torreon smelter stimulated mining considerably in the southern part of the State, and the Norias de Bajan, Cerralvo and Cuatro Cienegas silver-lead camps have been operated steadily.

Durango.—The Compañia Minera de Penoles at Mapimi is the most prosperous enterprise in the State. During 1902, 171,000 metric tons of ore were mined, producing 92,000 kg. of silver and 24,000 metric tons of lead. The quantity of ore produced at present exceeds 500 tons per day. The ore is found as a series of irregular pipes in Cretaceous limestone which have been explored to a depth of 2,300 ft. The ore bearing zone is developed by a number of main levels from which horizontal diamond drill-holes are run out on each side, 16 ft. apart and 200 ft. long. The whole area is grid-ironed. Thirty electric hoists are used in underhand stoping, varying from 1 to 50 H.P., and this method of development has proved to be the most successful in the opening up of ore reserves. This company pays $125,000, Mexican currency, in dividends per month.

Nuevo Leon.—This State produces 200,000 tons of lead carbonate ore per year. All the ore carries silver. The mines are located in parallel ranges, 20 miles apart, on the East Coast range of the Sierra Madre Mountains. The principal deposits are Villaldama and Montañas, and the Mitre, Voladon, Axtec an

Kara-Aidin, by a Turkish corporation capitalized at $290,000, which emplo 500 to 600 men. The corporation is the only concern in Turkey using ele tricity for power. The annual production averages from 4,000 to 6,000 to of metal assaying 82% lead and from 1·25 to 4% silver.

THE LEAD MARKETS IN 1902.

THE year opened with the same quotations as ruled at the end of 190 3·85@3·95c., St. Louis, and 3·95@4c., New York, but at the end of Janua the American Smelting & Refining Co. raised its prices 10c. per 100 lb. around, and also gave notice that in future orders for prompt shipment wou be executed only at 2·5c. per 100 lb. extra. This was done in order to induce co sumers and dealers to cover their requirements ahead, and to carry part of t available supplies which had accumulated at the refining works. Consequentl quotations quickly advanced to 3·95@4·05c., St. Louis, and 4·05@4·10c., Ne York, and have ruled at these figures ever since, with but small variations. proved impossible to bring about the same high range of values as that of t previous year (the average for 1902 is about 0·25c. per lb. lower than for 1901 owing to the danger of foreign lead being imported, even with a duty of 2·125 per lb. This was due to the fact that the European markets have been very mu depressed on account of bad business abroad and the constant fear of a deluge exports from the United States in the event of an advance. While the consum tion of lead in the United States has been very heavy—the demand for electric purposes, cables, etc., especially, showing a large increase—and while the stock existing at the end of 1901 have practically disappeared, it was necessary, i order to bring about the existing state of affairs, to have recourse to the same e pedients as those of last year, *i.e.*, to curtail the production of ores and expo certain quantities of domestic lead to Europe. This, naturally entailed a heav sacrifice, which, however, to a large degree, came out of the pockets of the o producers, as they were being paid for their lead only on the basis of 3·5c. per l Furthermore, it is reported that in some cases royalties were being paid for quan tities not mined, in order to pacify some of the recalcitrant miners. There ha also been a tendency on the part of the Trust to centralize the smelting of ore and the refining of lead bullion by closing down some plants and diverting ma terial to others. Some of the steps taken will probably have a beneficial effec in the future, in spite of the inclination in some quarters to decry these efforts But looking at the matter broadly, there are a good many which will tend to dis courage mining and prospecting operations in a large number of camps, and i that respect they are certainly a detriment and setback to the industry in general However, with the energy and enterprise characteristic of the American mining industry and the people therein engaged, there is no doubt but that in the cours of time, ways and means to a solution of this most difficult problem will be found The only producing center which benefited very largely by the continued high values is Missouri, where considerable strides forward have been made, resulting in a very heavy output.

[illegible]

White Lead, Red Lead, Litharge and Orange Mineral.

The aggregate production of lead pigments during 1902 was considerably greater than in 1901, the increase being distributed among all varieties except red lead and orange mineral, of which much smaller outputs are reported.

The production of white lead in oil during 1902 was 179,473,588 lb., valued at $9,755,197, as compared with 154,606,670 lb., valued at $8,978,441 in 1901, an increase in quantity of 24,866,978 lb. and in value of $776,756. The production of dry white lead in 1902 amounted to 49,841,821 lb., valued at $2,222,975, as compared with 46,966,945 lb., valued at $2,274,212 in 1901, which shows an increase in quantity but a decrease in value.

The production of red lead during 1902 was 23,338,252 lb., valued at $1,262,712, as compared with 26,206,096 lb., valued at $1,448,550, showing a decrease in quantity of 2,867,844 lb. and in value of $185,838.

The production of litharge during 1902 amounted to 25,510,690 lb., valued at $1,299,443, as compared with 18,913,036 lb., valued at $979,586 in 1901, an increase in quantity of 6,597,654 lb. and in value of $319,857.

There were produced 1,933,521 lb. of orange mineral, valued at $138,349 during 1902, as compared with 2,174,727 lb., valued at $224,667 in 1901, showing a decrease in quantity of 241,206 lb. and in value of $86,318.

The detailed statistics of the production and imports of the various lead pigments are given in the subjoined tables:—

UNITED STATES: PRODUCTION OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1898.....	9,160	$916,000	93,172	$9,391,738	7,460	$710,193	653	$88,937
1899.....	10,199	1,070,895	103,466	10,812,197	10,020	1,062,060	928	139,200
1900.....	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901.....	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902.....	11,669	1,262,712	114,658	11,978,173	12,755	1,299,443	867	138,349

(a) Includes both dry and in oil.

UNITED STATES: IMPORTS OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1898.....	682,449	$25,780	506,739	$24,384	56,417	$2,021	795,116	$37,745
1899.....	1,021,573	43,812	584,409	30,211	55,127	3,614	1,141,387	58,942
1900.....	549,551	25,532	456,872	28,366	77,314	2,852	1,068,793	61,885
1901.....	485,467	19,370	384,673	21,226	49,306	1,873	977,644	52,409
1902.....	1,075,839	37,383	506,423	25,320	88,115	2,908	997,494	49,080

In addition to the products stated in the foregoing table, the United States Reduction & Refining Co. at Cañon City, Colo., reported during 1902 an output of 4,000 short tons of "zinc-lead," valued at $225,000 as compared with 2,500 short tons, valued at $150,000 in 1901. This pigment is a mixture of oxidized compounds of zinc and lead made by an oxidizing smelting of lead and zinc ores in a blast furnace of special design. There were also produced by the Picher *Lead Co. of Joplin*, Mo., 4,736 short tons of "sublimed lead," valued at $449,611.

nercial importance. As noteworthy factors in the production of white lead there are now, in addition to the Dutch process, the Carter and the Bailey processes, both of which aim at the production of the same kind of lead as the Dutch, and the Dahl process under the management of W. J. Matheson & Co., which makes quick process lead by a precipitation method. The Gabel process aims to produce Dutch lead, and may become commercially important.

The Gabel process differs from the Dutch process in that the lead instead of being cast into buckles is shaved up into thin strips in a planer, the shavings being from 0·0625 in. to 0·25 in. wide and 0·01 in. thick. These shavings are filled into the pots which are so arranged that there is a free passageway for gases through a series of pots arranged one on top of the other, the bottoms of the pots being gratings which simply hold the mass of lead shavings in place. The grating in the bottom of each pot is surrounded by a rather deep channel which is filled with acetic acid. The pots when charged with lead and acid are placed in a wooden building provided with a double floor, the inner floor being perforated with a large number of holes to allow the carbon dioxide and air admitted through the space between the two floorings to enter the stack. A steam boiler is provided and both the steam from it and the carbon dioxide produced by the combustion of the fuel (coke) are allowed to enter the stack. The carbon dioxide is washed with water and freed from sulphur by passing through a dry purifier charged with iron oxide. The building in which the corrosion takes place is provided with windows through which the progress of the operation can be observed. The claim is made for the process, that the operation of converting the metallic lead into white lead is under perfect control, as all the elements of temperature, proportion of oxygen and proportion of carbon dioxide are changeable at will. It is also claimed that on account of the mechanical condition of the metallic lead, the time of corrosion is reduced to a third of that required for the Dutch process; also, that on account of the absence of tan-bark the lead produced is of better color than Dutch lead.

The manufacture of orange mineral of high grades has been commenced by the firm of Dahl & Ferguson, in New York, using Matheson's quick process lead as a starting point. The process is carried on in a reverberatory furnace fired with fuel oil. Quick-process lead is well adapted for the manufacture of orange mineral on account of the same peculiarities of physical condition which operate to limit its general use as paint.

Taking the history of recent years as a guide, it seems safe to predict that, first, the greatest technical developments in the manufacture of white lead may be looked for in some process which imitates the mechanics and chemical reactions of the Dutch process, and brings acetic acid, oxygen, and carbon dioxide into contact with metallic lead simultaneously; the Carter, Bailey, and Gabel processes, being examples of different means of attaining this result; and second, that the quick processes of which the Dahl is a type, and in all of which the characteristic feature is the separation of the solution of the lead as a soluble salt and the precipitation as insoluble basic carbonate into two distinct operations, will in all probability have a restricted but certain growth and will supply the users of white lead for other purposes than as white paint.

Recent Improvements in Lead Smelting.

By H. O. Hofman

Introductory.

... stone M. W. Iles has published a book entitled, "Lead Smelting, ... Pan-pneumatic and Operation of Lead Furnaces, and Observations ... of Metallic Elements on Slags and the Scientific Handling of ... The author has given his experience in practical work, which is not ... so far as facts more than principles are discussed. In order to ... the reader must be somewhat familiar with the details of ...

... Lead. Kahlbaum, Roth and Sweller[1] distilled metallic lead ... had done before them. The crystals thus obtained ap... octahedra and hexahedra, with octahedra prevailing. ... Mühlhauser[2] examined samples of sheet lead of F. W. ... Chicago, of the Raymond Lead Co., Chicago, and of a St. ... found that they contained 0.01%, 0.11% and 0.11% impurities.

The author compares these Missouri pig-soften leads with brands ... refinery plants, which contain arsenic and 0.01% im... Arsenic influences unfavorably the American brands of lead. The ... Berg- und Hüttenmännische Zeitung[3] calls the author's attention ... that exist between American "soft" and "corroding" leads ... Lead ... Pipes by Hofer. The recent actions by the Massa... of Health caused ... to be continued in Iowa and ... the former ... lead ... contain ... The ... the greater the ... the greater the ... the smaller was the ... ... upon the ... of the lead water ... lead and ... arising from the ... Massachusetts Board of Health ... the ... of oxygen and ... Hofer ... ... Where ... present the coal was ... ... to prevent ... water ... lead and ... the effect of oxygen. ... ... oxygen was ... ... The ... ... hexahedral lead ... The ... were necessary ... lead ... was ... ... The ... dissolved by boiled water ...

[1] Z. f. anorg. Chem. Vol. 7, p. 1 (1894).
[2] Chem. Zeitung (Cöthen) Vol. 18, p. 1... and Mühlhauser, Chem. Zeitung (Cöthen) Vol. 18, p. 1...
[3] Chem. Zeitung (Cöthen) Vol. 18, p. 1... and Die Berg- und Hüttenmännische Zeitung Vol. 53, p. 1...

... Chemical Journal Vol. 11, p. 1...
... Board of Health Report for ... Vol. 8, p. 1...
... Vol. 7, p. 1...

presence of certain salts seemed to protect the lead, especially sulphates, le carbonates and free carbonic acid. The effect of lime was found to be doub if sufficiently concentrated it might even increase the corrosion.

Melting and Boiling Points.—Lodin[9] volatilized galena in a current of ni gen at a temperature of 860°C.; galena melts at 935°C.

J. Guirochant[10] investigated the resistance of various metallic sulphides the passage of the electric current, and gives the following melting and boil points: Lead sulphide melts at 1,015°C., boils at 1,085°C.; tin sulphide m at 1,000°C., boils at 1,090°C., and iron sulphide melts at 925°C.

Lead-Tellurium Alloys.—The freezing points and microstructure of le tellurium alloys were investigated by H. Fay and C. B. Gillson,[11] who prepar a series of seventeen alloys containing from 2 to 95% tellurium. The result are given in detail under the caption "Review in the Progress of Metallograph during 1902," elsewhere in this volume.

Lead Ores of Southeast Missouri.[12]—Galena concentrates of Bonne Ter and Flat River carry small quantities of copper, some of which enters the le produced in smelting. Thus a sample of crude lead showed 0·2% copper which by liquating and poling was reduced to 0·02%. An analysis of a carload o concentrates gave Pb 62·10%, Cu 0·61%, Fe 3·33%, CaO 5·85%, MgO 3·08%, SiO_2 1·39% and silver 1·3 oz. per ton. Lime and magnesia are present as carbonates; which show the concentrates to contain $CaCO_3$ 10·45% and $MgCO_3$ 6·78%; and with the SiO_2 1·39% give 18·62% gangue. Iron and copper are present as pyrite and chalcopyrite, respectively.

Importation of Lead Ores.[13]—The decision of the Board of General Appraisers[14] in the case of lead ores and base bullion imported into the United States in bond, is to be contested.

Sampling Ores.—P. Johnson[15] describes the sampling mill which he built for the British Columbia Copper Co.'s smelting plant at Greenwood, B. C. The mill, 75 ft. long by 65 ft. wide by 58 ft. high, has a daily capacity of 1,000 tons ore, and is driven by a 100-H.P. engine. Fig. 1 represents a vertical cross section through the plant. The ore to be sampled is collected in an upper row of six bins (each 50 ft. long), some distance from the mill. From these the ore is discharged into scoop-cars of from 1 to 1·25 tons capacity, brought to the mill and dumped into the No. 5 Gates crusher, set to crush to a size of from 3 to 5 in. Lumps larger than 11 in. in diameter have to be broken by sledging. The crusher discharges the broken ore in the first Johnson sampler, making from 6 to 7 r. p. m., and cutting out 10% for the first sample, while the rejected ore goes into first ore bin. The sample is delivered into No. 2 Gates crusher, crushing to a size of from 0·75 to 1·25 in., and discharging into the second Johnson sampler, which makes 9 r. p. m., and cuts out three 20%

[9] *Comptes rendus*, 1895, 20, 1164.

[10] *Comptes rendus*, 134, 1224; *Zeitschrift fuer Electrochemie*, 1902, 8, 889; *Engineering and Mining Journal*, Dec. 27, 1902.

[11] *Transactions of the American Institute of Mining Engineers*, XXI., p. 586.

[12] *Engineering and Mining Journal*, Apr. 26, 1902.

[13] *Ibid*., Dec. 21, 1902.

[14] THE MINERAL INDUSTRY, 1901, X., 424.

[15] *Engineering and Mining Journal*, Apr. 12, 1902.

the latter case the first sampler is not rotated, but so placed that all the ore delivered into the first crusher passes through its sample-spout into the second crusher. Thus $\frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} = \frac{1}{125}$ part of the ore instead of $\frac{1}{250}$ part will go to the finishing room. In the same manner the second sampler may be cut out, when $\frac{1}{25}$ part of the whole will form the final sample.

The Johnson sampler, as shown in Fig. 2, consists of three parts; a top cone c attached to a revolving shaft, an inverted cone S_1 with opening O, and diverting

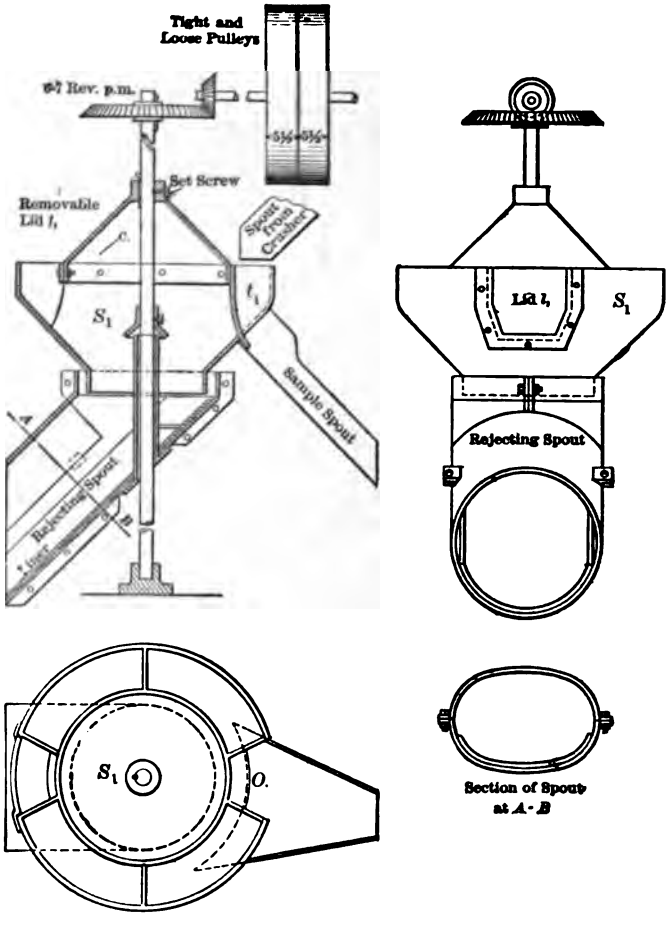


FIG. 2.—THE JOHNSON SAMPLER.

spout t bolted to the top cone, and a rejecting spout enclosing the bottom of the inverted cone. The stream of ore coming down the spout from the crusher passes into the rotating inverted hopper S_1 excepting when the opening O comes under the spout, when the tongue t_1 deflects the stream into the sample-spout. The segmental area of the opening is 10% of the entire circumference. *If the removable lid l, be taken off and a tongue put in its place, a 20% sample of the whole will be obtained.*

...smelter-size samplers have three openings instead of the single one *O*, ... the illustration.

... British Columbia Copper Co.'s works, two men draw the ore from ... the buggies, two men do the tramming, and two weigh the ore, dump ... crusher and break up lumps when necessary, one man attends to the ... two men take the ore from both sets of ore bins to the smelter ...

... sampled over [illegible] tons of ore, many lots were check sampled ... by the other parties. Examples of the work done are subjoined:

	Number of Tons	Copper per Cent.	Gold per Ton	Silver per Ton					

... Mr. [illegible] in Part I. [illegible]

... [illegible]

... [illegible]

...

front-irons, the dividers to the back-irons. The frames are attached by m of connecting rods to two eccentrics, which are driven by a 3-in. belt on a 1- pulley, and make 150 oscillations per minute. The length of stroke is so adju that the hopper shall discharge the entire content alternately into the san and the discard-channel of the dividing trough. The ore, crushed to pa 1-in. ring, is fed through the 4-in. pipe at the top; it strikes the oscilla hopper, where it is mixed and dropped alternately into the sample- and dis channels of the rapidly-moving divider. The discard gliding down the card-channel is delivered into the top-opening of the discard-chute, while

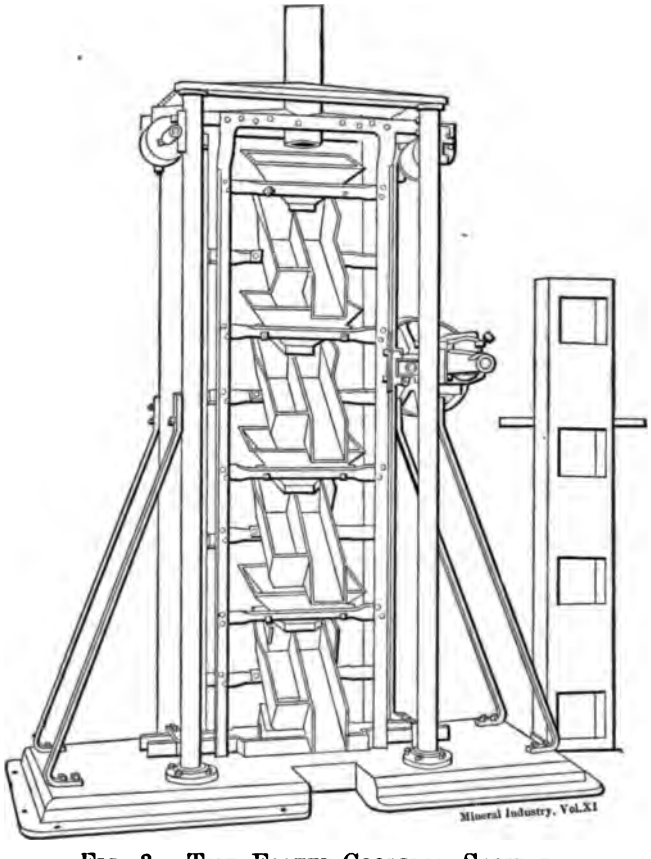


FIG. 3.—THE FOSTER-COOLIDGE SAMPLER.

sample gliding down the sample-channel, strikes the lower end and falls thr the opening in the bottom into the second hopper, and thence into the se divider, where the operations are repeated, and so on down through the third fourth hoppers and dividers, the final sample being delivered into a san chute extending through the cast-iron base. The power required to drive machine is small. The sampler is 7 ft. 3 in. high and occupies a floor-s 5 ft. 10 in.×2 ft. 9 in. Its capacity per hour is said to be from 25 to 30 of ore or matte.

flour 5 g.; borax glass 3 g., sprinkled on top, and salt cover, nails as need Fusion is started at a low heat, which is gradually raised. The fusion sho be completed in from 35 to 40 minutes. Another flux is: sodium bicarbona 125 g.; potassium carbonate, 162 g.; raw borax, 63 g.; flour, 51 g. With mu calcium and barium oxide, more borax is added. Nails are always used.

With ores high in antimony, the author prefers to determine lead volumetri cally by the molybdate instead of using a dry method, for which Ricket recommends: ore, 10 g., sodium or potassium carbonate, 35 g., niter, 1 g. salt cover; the charge to be fused 20 minutes at a good heat, then cooled slowly for 10 minutes, and finished at a high heat in 10 minutes. The idea is that part of the antimony will be taken up by the flux, part will be volatilized, and very little only will be taken up by the lead.

O. J. Frost[26] modified the common method for assaying galena concentrates from northern Idaho (Pb from 40 to 60%), by dropping 10 g. KCN into the crucible about five minutes after complete fusion of the charge, and then heating for 15 minutes. With the use of KCN overheating must be avoided, as there is danger of the charge boiling over. The following table of comparative results is of interest:—

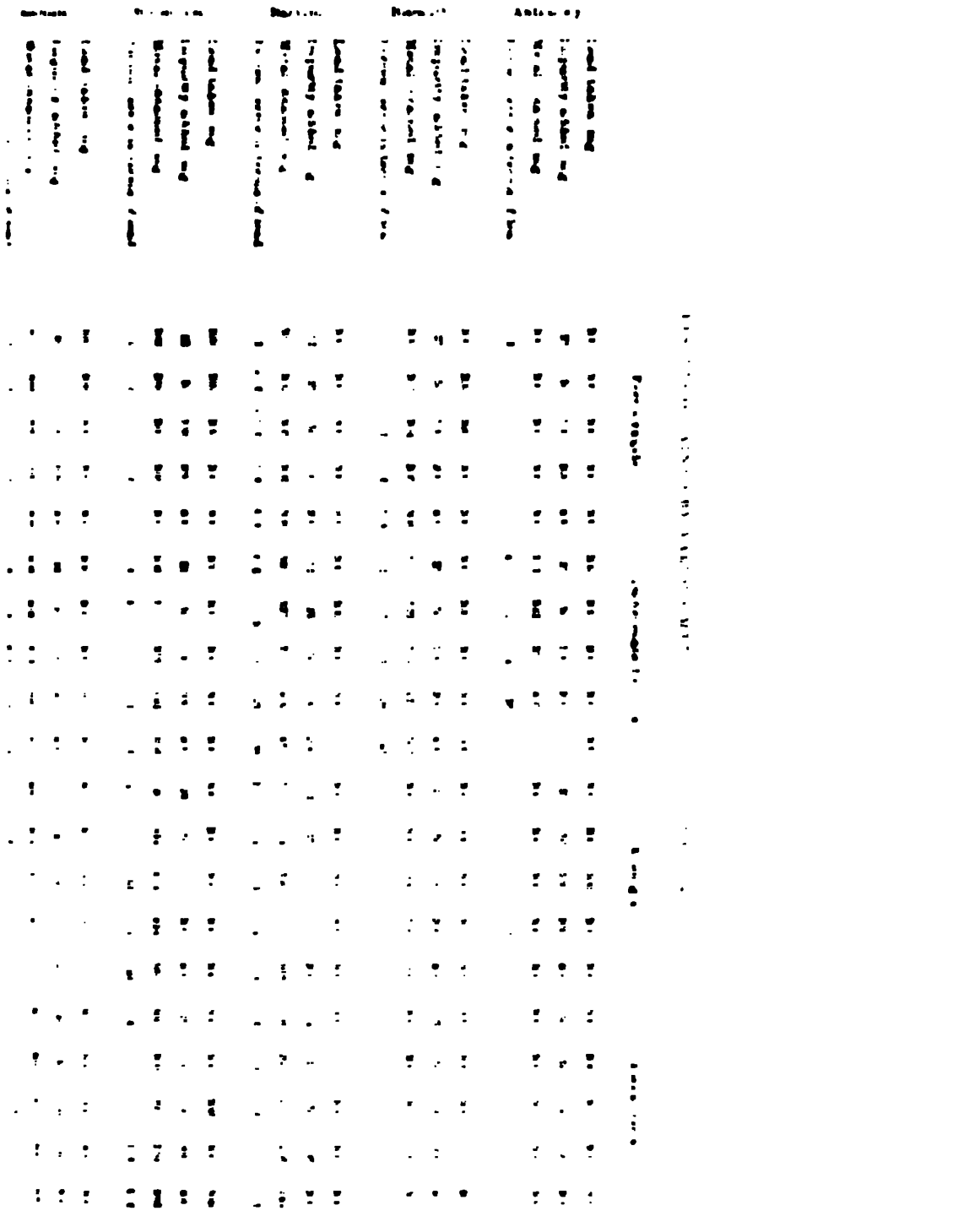
Without KCy.	With KCy.	Wet Assay (Molybdate Method).	Without KCy.	With KCy.
%	%	%	%	%
44·6	45·5	45·56	55·9	53·57 and 53·55
49·9	50·4	50·40	49·2	50·23 and 50·19
55·6	56·2	56·32	45·5	45·9 and 45·88
.....	55·62 and 55·51	55·87 and 55·68	46·6	47·2 and 47·22
57·4	58·27 and 58·00		45·8	46·53 and 46·32
56·5	57·56 and 57·45		48·2	49·04 and 48·98
56·0	56·44 and 56·76		45·3	46·12 and 45·95
60·4	60·85 and 60·92		45·7	46·18 and 46·27

I. C. Bull[27] has investigated the determination of lead in ores. Six different ores containing as leading lead-bearing minerals galena (two), cerussite (two), sulphuret-galena-sphalerite (one), and galena-stibnite (one), were assayed for lead in the dry way, gravimetrically by the lead sulphate and lead chromate methods, electrolytically by the lead peroxide method, and volumetrically with the ammonium molybdate (D. H. H. Alexander), the oxalic acid and potassium permanganate, potassium dichromate, potassium ferrocyanide, and lastly with the original and modified methods of Koenig. The influence that antimony, bismuth, barium, strontium and calcium have on the volumetric methods were also determined.

The data tabulated show that the dichromate method is liable to give results that are too high; the same is the case with Koenig's method, though to a less degree. The ferrocyanide and molybdate (Alexander's) methods are preferable to the other two. The results obtained are shown in the tables given on the next and following pages of this section.

The results in the table show that the molybdate or Alexander's method, the dichromate or back titration method with either ferrous salt or sodium thiosulphate, the Koenig and the ferrocyanide methods give concordant results

[26] *Engineering and Mining Journal*, May 17, 24, 1902.
[27] *School of Mines Quarterly*, 1902, 23, pp. 348–366.



In the preceding table are brought together the data showing to what degree antimony, bismuth, barium, strontium and calcium interfere with the results of the above-mentioned four volumetric methods.

RESULTS OBTAINED BY VARIOUS METHODS OF DETERMINATION.

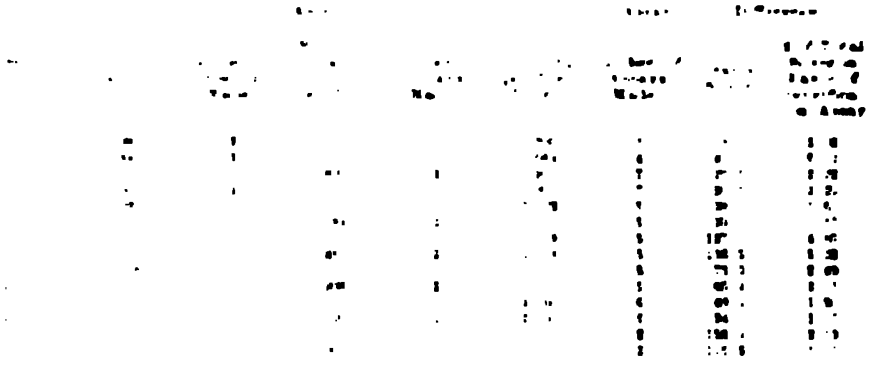
Number of Ores.	Fire Assay.	Lead Sulphate Method.	Lead Chromate Method.	Electrolytic Method.	Alexander's Method.	Koenig's Method.	Oxalate Method.	Dichromate "Ferrous" Method.	Dichromate "Hypo" Method.	Ferrocyanide Method.
	%	%	%	%	%	%	%	%	%	%
I.....	76	78·68	78·71	78·73	78·74	78·60	77·54	78.71	78·76	79·67
	.....	78·62	78·68	.....	78·82	78·64	77·60	78·78	78·73	79·68
II.....	37	37·20	37·28	37·35	37·41	37·38	36·71	37·32	37·33	37·81
	.....	37·26	37·30	.....	37·44	37·40	36·62	37·38	37·37	37·79
III.....	9	10·76	10·77	10·80	10·80	10·58	9·92	10·78	10·80	10·92
	.....	10·74	10·74	.....	10·83	10·62	9·98	10·72	10·76	10·90
IV.....	24·7	18·40	18·45	18·58	18·47	18·46	17·54	18·48	18·50	18·64
	Base Metal,	18·43	18·40	.....	18·51	18·42	17·65	18·44	18·45	18·68
V.....	26·7	27·25	27·23	27·32	27·44	27·24	26·28	27·31	27·26	27·78
	.....	27·21	27·20	.....	27·35	27·56	.....	27·27	27·32	27·78
VI.....	37·8	38·50	38·47	38·60	38·66	38·60	37·38	38·46	38·57	38·81
	.....	38·54	38·50	.....	38·58	38·68	.....	38·52	38·60	38·86

Assay of Lead in Slags.—Svoboda[28] worked out the following wet method for the determination of lead in blast-furnace slags: Place 10 g. finely pulverized slag in a covered beaker, add 10 c.c. water, stir, add quickly while shaking, 50 c.c. conc. hydrochloric acid, dilute with 30 to 40 c.c. water, and boil until free from hydrogen sulphide. Add carefully potassium chlorate to peroxidize the salts, remove excess of chlorine by boiling, filter through a large folded filter into a beaker holding 1,500 c.c., and wash three times with boiling water. Return filter with residue to original beaker, boil with water, filter through second folded filter, using the same funnel as before (the filtrate to be run into the first filtrate), and wash two or three times with boiling water.

The residue is free from lead, all the lead having gone into solution. Add to the filtrate 20 g. granulated zinc (free from lead), allow to stand over night, then filter and wash three times with cold water. Transfer filter with precipitated lead and residual zinc to a beaker, add nitric acid to dissolve lead and zinc, transfer to a 250-c.c. flask, cool, fill to the mark and filter. Take 200 c.c. of the filtrate (=8 g. slag) add 25 c.c. dilute sulphuric acid (1·4), and when the lead sulphate has settled out, add 70 c.c. absolute alcohol, and allow to stand over night. Then filter through a Gooch crucible, wash with 30%, then with 100% alcohol, and finally with ether, dry at 150°C., cool and weigh. The lead sulphate thus obtained is as a rule C. P. If there is any doubt, dissolve it in concentrated ammonium acetate, wash and again weigh the crucible. In order to obtain check results, the lead dissolved by ammonium acetate was precipitated as lead sulphide, and weighed as such. Results obtained are tabulated below:—

Per Cent. Lead from	First Set. Sample No.										Second Set. Sample No.						Third Set. Sample No.				
	1	1a	2	3	4	5	6	7	8	8a	9	10	11	12	13	14	9	10	11	12	13
Lead Sulphate..	3·30	3·09	3·39	3·66	3·73	4·19	1·93	....	1·83	1·64	2·39	4·79	2·51	2·41	2·58	2·73	2·51	4·68	2·66	....	2·39
Lead Sulphide...	3·36	3·14	3·50	3·69	3·73	4·30	2·03	1·74	1·83	1·66	2·29	4·78	2·59	2·42	2·57	2·76	2·54	4·74	2·76	....	2·43

[28] *Oesterreichische Zeitung fuer Berg- und Huettenwesen*, 1902, 582.



of litharge that is to carry the copper into the slag, with sufficient silica have 1 part silica to 16 parts litharge, also the necessary oxidizing or reducing agents to obtain a button weighing 16 g. The fusions carried out in the muffle will give the best results when starting with the muffle fairly red; in 30 minutes this becomes a bright red, when the charge is kept in the furnace 10 minutes longer. The slag obtained will pour well, and when allowed to solidify should show when broken, lead, copper and iron silicate on the outside edge, gradually passing into crystalline litharge toward the center. If the furnace is too cool the slag will be crystalline, and shots of lead are liable to remain in the crucible; if too hot, the slag corroding the crucible will show cavities which may retain lead. In making up the charges, it is important to know the contents of copper, silica, iron, and sulphur of the ore, and the effects of the fluxes. 1 g. flour will reduce 10 g. lead; 4% sulphur, 16 g.; 4% antimony, 3 g.; 4% arsenic, 6 g.; and 1 g. potassium nitrate will oxidize 4 g. lead. The quantity of litharge used will depend, besides silica to be slagged, upon the impurities to be fluxed. With low-grade ores (from 2 to 4% copper), 5 A.T. litharge will be added to 0·5 A.T. ore; with matte (from 48 to 60% copper), 8 A.T. litharge will be charged with 0·1 A.T. matte. For example, an ore of the composition: copper 5·4%, silica 29·4%, iron 28·2%, lime 13·1%, sulphur 15·8% may be taken. Being rich in copper, 0·25 A.T. will be weighed out so as not to make the charge too large. This will require 8 A.T. litharge, 0·5 A.T. sodium and potassium carbonates, 18·3 g. silica, and 4 g. potassium nitrate. The author always uses a salt cover having found the results to be more satisfactory than with borax. Arsenic and antimony interfere with the method only when together they exceed 4% in quantity.

W. H. Kauffman[34] investigated the losses in silver in cupelling; he varied the quantities of silver and lead taken, the kind of cupel, and studied the effects of copper. The cupels were of three kinds: water cupels, potash cupels and borax cupels. In the first, 3,000 g. bone ash were moistened with 393 c.c. water; in the second, 60 g. pearl ash were dissolved in the water; in the third, 20 g. borax. The results obtained are given in the subjoined tables, each assay-figure being the average of several determinations.

Water Cupels.						Potash Cupels.			
Silver Charged.	Silver Lost.	Lead Charged.				Silver Charged.	Silver Lost.	Lead Charged.	
		5 Grams.	10 Grams	15 Grams	20 Grams			10 Grams	25 Grams.
Mg.	Per Cent.	%	%	%	%	Mg.	Per Cent.	%	%
25		2·14	2·63	2·69	2·09	25		2·38	2·48
50		1·43	2·23	2·14	1·86	50		2·10	2·25
100		1·30	1·61	1·68	2·12	100		1·89	1·93
200		0·86	1·24	1·40	1·74	200		1·29	1·45

Borax Cupels.				Water Cupels.				
Silver Charged.	Silver Lost.	Lead Charged.		Silver Charged.	Copper Charged.	Silver Lost.	Lead Charged.	
		10 Grams.	25 Grams.				10 Grams.	25 Grams.
Mg.	Per Cent.	%	%	Mg.	Mg.	Per Cent.	%	%
25		2·43	2·44	100	20		1·61	1·82
50		1·96	2·37	100	50		1·80	1·99
100		1·42	2·12	100	100		1·87	2·01
200		1·17	1·76					

[34] *Engineering and Mining Journal*, June 14, 1902.

fusing-hearth; it passes in 30 hours through the furnace; the sulphur is reduced from 15% to about 4%. The blast furnace plant at Herculaneum has three water-jacket furnaces 54 in. in diameter at the tuyeres and 12 ft. high (each furnace treating from 50 to 60 tons charge in 24 hours), and one oblong furnace, 54×180 in. at tuyeres and 12 ft. high, with a capacity of from 60 to 80 tons charge in 24 hours. A charge contains about 50% lead; the slag aimed for is SiO_2 30%, FeO 40%, CaO 12 to 14%. Matte and slag are tapped into conical pots, 2 ft. in diameter at the top, and separated on the dump when cold. The matte, with 10% lead, is roasted in a Pearce single-deck turret furnace, and the sulphur reduced to 4%. The roasted matte is smelted in the blast furnace. Concentration of copper, nickel and cobalt in the presence of lead cannot be carried beyond a certain limit without cobalt and nickel being slagged to a considerable extent. The lead is run through an Arent's siphon tap into a kettle and cast into 80-lb. bars, which are sent to the refinery. The refinery contains two liquating furnaces with trough-shaped hearths, consisting of two cast-iron plates 3×5 ft. and 2 in. thick, which discharge the liquated lead through holes bored 8 in. apart, into semi-circular troughs. These deliver the lead into two merchant kettles, where it is poled for 90 minutes with steam passing through a 1-in. pipe. A kettle 3 in. thick at the bottom and 2 in. at the sides holds 30 tons of lead. The contents of the two kettles are discharged by means of Steitz siphons into 50 double moulds supported by the horizontal frame of a circular revolving picking table. The wheel-shaped table has 50 spokes. One central stack furnishes the draught for the two liquating furnaces and the two poling kettles. The market lead assays 1·5 oz. silver per ton.

Lead at Freiberg, Saxony.—Kochinke[37] publishes a tree of the ore treatment of the Halsbrücken and Mulden smelting and refining works, Freiberg, Saxony, which gives full details of the modes of working these complex ores.

Lead at Laurion, Greece.—Ernst[38] discusses briefly the smelting of lead ore, cupellation of argentiferous lead, and the uses to which lead and litharge were put by the ancients. The smelting methods must have been very imperfect, as old slags contain from 7 to 14·5% Pb. The litharge found, however, contains less than 3 oz. silver per ton, showing that the ancients were very careful with cupellation. Older silver coins upon analysis give a fineness of from 983 to 986, while those of a later date gave 966 and even 919 fine, which was probably due to the ores having become more base or to less care in the cupellation.

Lead in Murcia, Spain.—According to Jannetaz[39] the ore treated at Murcia, Spain, is mainly a galena concentrate with from 50 to 55% lead. The mines contain also a ferrous-lead-silicate ore with 6% lead, which is used as flux. The galena ore is roasted in hand reverberatory furnaces with hearths from 40 to 46 ft. long and from 10 to 13 ft. wide. In 24 hours from 5·5 to 6 tons ore are roasted with a fuel consumption of from 16 to 18% of the weight of the ore. The former natural draught furnaces have been superseded by blast

[37] *Freiberger Jahrbuch*, 1902, 96-98.
[38] *Oesterreichisches Jahrbuch*, 1902, 50, 475; Hofman, *Engineering and Mining Journal*, Oct. 21, 1893.
[39] *Memoires et Compte Rendus des Travaux de la Société des Ingenieurs Civils de France*, 1900, I., 705-711; *Transactions of the Institution of Mining Engineers*, 1900-1901, 20, 583.

ing furnace in which travel a row of trucks, forming parts of the hearth. The trucks are coupled at the ends, the sides run in grooves sealed with sand. The furnace is heated in the usual way from external fire-places, the trucks receive their ore charges at one end of the furnace, pass slowly through and leave it at the other. The ore is rabbled by hand from the sides.

D. C. Jackling[43] has patented a mechanical roasting furnace and carriage. The furnace has an oblong stationary hearth; its roof is carried by skew-backs riveted to upright I-beams, the tops of which are joined by cross beams which carry the return track of the carriage as well as a corrugated floor forming the cooling hearth for the roasted ore. The carriage runs on rails placed inside the furnace walls.

W. A. Lorenz[44] patented a straight-line mechanical reverberatory roasting furnace assigned to the Lanyon Zinc Co., of St. Louis, Mo. The stirring mechanism is the opposite of that of Ropp, in so far as it is suspended by rods carried by trucks running on a track above the furnace instead of being supported by rods carried by trucks running in a vault underneath the hearth. In order to give the roof (which is divided into two parts by the longitudinal slot) the necessary strength, it has two arches, and as there is no abutment along the median line for the meeting arches, a heavy iron casting, firmly attached to steel cross beams, takes its place.

D. Sheedy and M. W. Iles[45] have patented an oblong mechanical roasting furnace, in which the abutments carrying the arch are built into cast-iron angles. These are suspended by iron rods from cross beams, and braced against the vertical beams of the upright frames extending over the furnace. The rabble carriages run outside of the furnace, and make their return trips on rails placed on the cross beams.

J. P. Cappeau[46] has patented a mechanical straight line reverberatory furnace similar in principle to the Ropp furnace. The improvement lies in the opening and closing of the central slot in the hearth by means of gates, which are controlled by the rake as it moves over the hearth.

The case of Horace F. Brown against the Lanyon Zinc Co.[47] for the infringement on the Brown patented roasting furnace was decided by the Circuit Court of Appeals in favor of Brown, thus upholding the decision rendered by the Circuit Court of Kansas.

A. D. Carmichael[48] has proposed to desulphurize ores by mixing them with calcium sulphate, and then heating to start the roast. The heat generated is to reduce the calcium sulphate to sulphide, and the latter is to be re-oxidized by the admission of air.

J. A. Ogden[49] has patented a gravimetric ore roaster by which term is to be understood a reverberatory furnace containing suspended shaking iron plate. The ore is to be subjected to dry concentration while it is being roasted.

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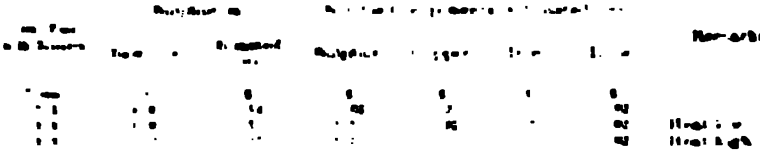
[43] United States Patent Nos. 706,755 and 706,756, Aug. 12, 1902.
[44] United States Patent No. 691,787, Jan. 28, 1902.
[45] United States Patent No. 711,352, Oct. 4, 1902.
[46] United States Patent No. 691,112, Jan. 14, 1902.
[47] *Mining and Scientific Press*, Sept. 13, 1902.
[48] United States Patent No. 705,904, July 29, 1902.
[49] United States Patent No. 691,868, Jan. 28, 1902; No. 709,782, Sept. 9, 1902.



circulates beneath the inclined iron roasting hearth, cools this and enters when superheated in part, under the grate of the deep fire-place of the furnace.

An editorial[58] gives brief descriptions of the newly patented roasting furnaces of P. Argall, [59] J. P. Cappeau,[60] H. Carmichael,[61] B. Hall,[62] W. A. Lorenz,[63] Th. D. Merton,[64] U. Wedge,[65] J. P. Wetherill,[66] L. T. Wright,[67] and F. W. Holtman.[68] The last-named furnace is a modification of the Spence furnace. The rakes are moved to and fro by means of threaded rotating shafts, the directions of which are reversed after each movement of the rakes. The shafts are mounted outside of the furnace, and are driven by bevel gearing. The rake arms protrude from the hearths through the sides of the furnace, the continuous slots being closed by long plates attached to the arms. Other patented roasting furnaces are those of A. M. Beam,[69] W. H. Mother,[70] P. Naeff,[71] Th. Edwards,[72] and A. C. Johnson.[73]

Blast-Furnace Table.—The blast-furnace table of Kochinke[74] contains several statements about the Przibram smelting works, which require a correction. According to Cap[75] the coke consumption during the last 28 years was 13·18%, and during the last 5 years 12·6%; it never reached 16% as stated by Kochinke; the coke often containing from 13 to 15% ash. Further, the diameter of the hearth is 4·92 ft., not 4·59 ft.; the diameter of tuyeres 2·27 in., not 2·36 in.; the blast pressure is 1 in. quicksilver, not 1·6 in.; the charge contains 16% lead, the ore 32% silica.

Blast-Furnace Construction.—C. Laughlin[76] has patented a slag-escape device for a blast-furnace tuyeres, and a means of cooling a wrought-iron water-jacket by making connection near top and bottom with a water tank. The idea of the second patent is that the hot water in the jacket will, while rising, draw in cool water near the bottom, and thus establish a circulation of the cooling water. The heated water is cooled in the open water tank.

E. H. Messiter[77] has patented a tuyere-elbow with a drop-valve, which prevents the back flow of gas into the bustle pipe, should the pressure in the tuyere-pipe be reduced below that prevailing in the furnace. Between the drop valve and the opening leading into the furnace is an escape passage leading in the open air, the passage being controlled by the pressure of the blast.

M. Barrett[78] has patented a sectional, water-cooled tapping-jacket for a matte settler.

Mechanical Feeding of Blast Furnaces.—A. S. Dwight discusses the mechanical feeding[79] of silver-lead blast furnaces, and gives much information in regard to the mechanical factors that govern the successful working of a lead blast fur-

[58] *Engineering and Mining Journal*, Aug. 16, 1902.
[59] THE MINERAL INDUSTRY, IX., 445. [60] *Ibid.*, XI., 440. [61] *Ibid.*, X., 429. [62] *Ibid.*, X., 429. [63] *Ibid.*, XI., 440. [64] *Ibid.*, XI., 441. [65] *Ibid.*, IX., 445. [66] *Ibid.*, X., 430. [67] *Ibid.*, VIII., 401 and XI., 441.
[68] United States Patent No. 664,153, Dec. 8, 1900.
[69] United States Patent No. 708,615, Sept. 9, 1902.
[70] United States Patent No. 708,977, Sept. 9, 1902.
[71] United States Patent No. 711,388, Oct. 14, 1902.
[72] United States Patent No. 715,080, Dec. 2, 1902.
[73] United States Patent No. 714,464, Nov. 25, 1902.
[74] THE MINERAL INDUSTRY, X., 430.
[75] *Oesterreichische Zeitschrift fuer Berg- und Huettenwesen*, 1902, 147.
[76] United States Patent Nos. 707,601 and 707,602, Aug. 26, 1902.
[77] United States Patent No. 706,332, Aug. 5, 1902.
[78] United States Patent No. 701,670, June 3, 1902.
[79] Paper read before the American Institute of Mining Engineers, November, 1902.

in pieces about 6-in. diameter, coke ought to be somewhat broken, and a reasonable quantity of fines left with the larger pieces. Moistening of charge helps to pack the ore tightly, and to keep the heat down. While the evaporation of water consumes fuel, the loss in heat is smaller than that experienced from the smelting zone creeping up.

In the open-top furnace the fine particles when falling from the shovel, will drop near the center, the coarser particles acquiring a greater momentum will fall nearer the wall of the furnace. A similar arrangement will occur with the Pfort curtain. In the side-fed or hooded furnace the fines drop near the wall, while coarse ore is thrown more toward the center, as it ought to be. If a mechanical feeder can be constructed which will feed the fines toward the side and the coarse toward the center, there is no question of the mechanical

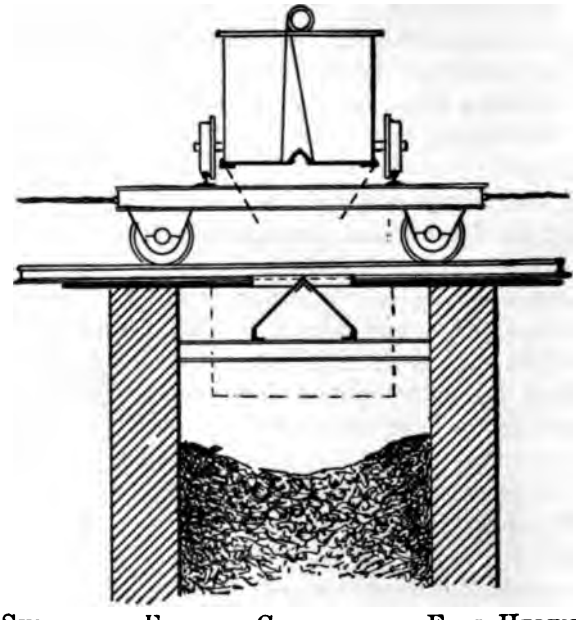


FIG. 4.—SYSTEM OF FURNACE-CHARGING AT EAST HELENA, MONT.

feeding being preferable to hand feeding. Mechanical feeders are in use at the Pueblo, East Helena, Salt Lake City and El Paso works of the American Smelting & Refining Co., and are being adopted at the new plant at Torreon, Mexico. The author reviews with illustrations, the different mechanical devices that have been tried, discusses some details of the arrangement at Pueblo and East Helena. Fig. 4 is a sketch of the East Helena system adopted in 1900. It shows the charge car with curtains (now omitted) in the transfer carriage, and the roof-shaped spreader which deflects the charge toward the sides where the fine ore remains, while the coarse parts roll toward the center.

With this arrangement, as with most others, the contents of the car have to drop quite a distance before they reach the charge in the furnace. W. H. *Howard*[70a] avoids this disadvantage by his improved blast furnace charge feed,

[70a] Private communication.

Hole.	CO_2.	CO.	$\frac{CO_2}{CO}$.
A.....	5·1	20·4	0·25
B.....	6·1	30·3	0·20
C.....	7·8	21·8	0·36
Flue leading to stack..	1·5	1·1	1·36

The analyses show extraordinary high values for carbon monoxide. Th an indication that carbon at the tuyeres burnt mainly to carbon monoxide, that up to the level C of the furnace, where the last gas samples were t indirect reduction was subordinate to direct reduction. The absence of ox hydrogen sulphide and sulphur dioxide in the gases shows that no uncons air passed through the furnace, that neither the water vapor of the air no solid oxygen of the iron ore had any effect upon the sulphides in the ch and that no carbon oxysulphide (sulphur acting upon carbon monoxide) formed, which being decomposed by water would give carbon dioxide and h gen sulphide. The ratio of 1·36 of the gases in the flue leading to the shows that considerable carbon monoxide must have been oxidized to di above the point C. This may have been caused by carbon monoxide acting reducing agent upon a readily reducible oxide (litharge *e.g.*), or by its bu at the surface of the charge when it came in contact with the air.

The furnace at St. Andreasberg, of the same general dimensions as th at Altenau had four tuyeres 1·34 in. in diameter; it was running on foul furnace slag when the investigations were being made. The ore bed, conta 5·89% sulphur, was made up of 56,100 kg. lead matte (SiO_2 2·05%, Pb 13· Cu 7·68%, Sb 0·31%, Zn 4·73%, Fe 44·73%, Mn_2O_3 1·01%, CaO 0· S 24·32%); 1,400 kg. burnt pyrite (S 5%); 23,200 kg. drosses (Pb 30 to S 2%); 30,400 kg. speiss (S 3%); 4,300 kg. fume (S 9%); 34,800 fu refuse (S 10%, *e.g.*, PbS 95·5%, FeS 3·2%, Sb_2S_3 2·5%), and 211,300 kg. slag (S 2%). It was smelted at the rate of 12·1 metric tons per day 8·8% coke (S 1·5%); the blast pressure was 3·14 in. water correspondi 282·3 cu. ft. air per minute. Five holes were drilled through the furnace to draw off gases: hole *a* was 0·49 ft., *b* 2·36 ft., *c* 3·71 ft., *d* 5.41 ft. and *e* 6· above the level of the tuyeres. As the Altenau tests had shown that the su of the charge was not oxidized during its descent in the furnace, it seemed terest to find out here what effect water vapor might have upon coke. The set of tests is brought together in the accompanying table.

Hole.	Blast Pressure. cm. Water.	Grams Water. In 1 Cu. M Air.	Grams Water. In 1 Cu. M. Furnace Gas.	Difference.	Grams Fume in 1 Cu. M. Furnace Gas.	H_2S.	SO_2.
a.....	8	9·2	8·8	—0·4	29·9	None.	None.
	8	9·2	8·9	—0·3	29·6	None.	None.
b.....	8	10·0	9·3	—0·7	11·7	None.	None.
	8	10·0	9·5	—0·5	11·8	None.	None.
c.....	10	12·0	12·0	0·0	7·0	None.	None.
	10	12·0	12·4	0·4	7·3	None.	None.
d.....	10	13·6	16·5	2·9	6·6	None.	None.
	14	13·6	47·3	33·7	7·2	None.	None.
	14	13·6	47·8	34·2	7·3	None.	None.
	24	13·6	n. d.	.....	13·1	None.	None.
	24	13·6	n. d.	.....	13·3	None.	None.
e.....	8	11·3	82·9	71·6	6·2	None.	None.
	8	11·3	83·0	71·7	6·4	None.	None.

when fluid, are not isomorphous, and are incapable of combining chemically with one another.

By means of the new system of plotting, it is easy to enlarge upon the facts found by Hofman regarding the changes in formation temperatures caused by replacing the different slag constituents, and to show what effects leaving out one or another constituent without replacement will have upon them.

H. von Jüptner[85] discusses mainly from the iron metallurgist's point of view, the relations that may obtain between the sulphur content of metal and slag. The general considerations he brings forth have an important bearing on the sulphur contained in matte and slag; he exemplifies this by examples of copper-matte and blast-furnace slag.

I. H. L. Vogt[86] discussed in a general way the behavior of melted silicates, and showed the application of the general laws of solution to silicates as well as to alloys. According to his view, melted silicates are igneous solutions of compounds in stoichiometrical proportions.

Waste Heat of Blast-Furnaces.—R. Brown[87] proposes to utilize the heat of the waste products of smelting furnaces by transferring it to the materials to be charged into the furnace. The charge is to be dropped into a closed chamber with perforated iron floors, beneath which pass the cars containing the furnace products.

Flue-Dust.—F. H. Long[88] has patented a metallurgical filter, which consists of a sheet-iron cylinder with conical bottom carrying a spreader, a spiral baffle and a filtering medium. Dust-laden gases are forced by means of a fan into the cylinder at the apex of the conical bottom, and through the filtering medium and drawn off, freed from dust, by means of an ejector. The apparatus thus works with pressure on one side of the filter and with a vacuum on the other. Details of arrangement of filter and of filtering medium are not given.

W. J. Jackson[89] patented a wet smoke condenser.

Briquetting of Ores.—R. Schorr[90] briefly reviewed the different bonds and methods employed in briquetting fines; he estimates the cost of briquetting to range from $0·65 to $1·25 a ton of briquettes.

Chisholm, Boyd & White[91] has published an illustrated description of their well-known briquetting machine, which consists of a lime slacker, an automatic feeding and measuring device, a conveyor mixer, and the press proper with belt-conveyor.

W. G. Irwin[92] has reviewed the briquetting of fuels and ores in general, and praises the White (Pittsburg) press. The paper is illustrated, and reproduces the well-known illustrations of the manufacturer.

H. Bumby[93] has discussed in detail the briquetting of finely divided iron ores.

[85] *Stahl und Eisen*, 1902, 387 and 432.
[86] *Chemiker Zeitung*, 1902, No. 21, p. 230.
[87] United States Patent No. 708,018, Sept. 2, 1902.
[88] United States Patent No. 691,706, Jan. 21, 1902.
[89] United States Patent No. 700,934, May 27, 1902.
[90] *Engineering and Mining Journal*, Nov. 22, 1902.
[91] *Mining and Scientific Press*, July 12, 1902.
[92] *Engineering Magazine*, 1901-02, 22, 889.
[93] West of Scotland Iron and Steel Institute, Feb. 21, 1902, through Stahl und Eisen, 1902, p. 457.

ducing lead from galena without the use of carbonaceous fuel, which is based upon the following thermochemical considerations. Upon blowing a measured quantity of air through molten galena there are set free sulphur dioxide and metallic lead, at the same time some lead sulphide is sublimated in the form of a black fume. The reaction taking place may be expressed by

$$2PbS+2O=SO_2+Pb+PbS.$$

It is exothermic, and the heat set free by burning one-half of the sulphur of the charge is sufficiently large to melt and liquefy a new charge of galena of the same weight as the original charge. As any silver present in the galena remains with the liberated metallic lead, the sublimated lead sulphide, now free from silver, will furnish non-argentiferous lead when treated by the same process. If, instead of burning off only half of the sulphur, the oxidation is carried periodically further, the sublimated lead sulphide will be converted into lead oxide and sulphate. The dark and white fumes obtained in the two oxidation periods are collected in separate condensing chambers, then mixed and treated as would be galena, when lead and sulphur dioxide will be formed, the oxidation of part of the lead sulphide furnishing the necessary heat:—

$$PbS+O_2=Pb+SO_2 \text{ and}$$
$$PbSO_4+PbS=2Pb+2SO_2$$
$$2PbO+PbS=3Pb+SO_2.$$

The reactions require a galena with 75% lead or more. With ore of a lower grade, carbonaceous fuel has to be used to slag the gangue; the slag being rich in lead will have to be treated separately.

Electrolytic Reduction of Galena.—P. G. Salom[100] and J. W. Richards[101] describe the electrolytic reduction of galena carried on by the Electrical Lead Reduction Co., at Niagara Falls, N. Y. Finely crushed galena is spread to the thickness of 1 in. on the bottom of conical hard-lead reduction pans (from 15 to 18 in. in diameter and 18 in. deep, with sides protected by a rubber coating) and then some sulphuric is added. Eleven pans (cells) are stacked, one on top of the other, to form a pile; the bottom of the top pan forms the anode of the adjoining lower one, in which galena forms the cathode. A pile (or stack) of cells containing 33 lb. galena is electrolyzed in 5 days by means of a current of 33 amperes at 2·9 volts. In this process the ore is reduced to spongy lead which swells to a thickness of from 3 to 4 in.; the sulphur passing off as hydrogen sulphide, together with the hydrogen that is generated, is conducted away in pipes and burned. The spongy lead, when washed and dried is ready for use in a storage battery. At present, most of the lead sponge is burned in a furnace and converted into litharge. The plant has two Westinghouse 300-H.P. motors run by an alternating current of 2,250 volts. Each motor is directly connected with a Westinghouse direct-current 250-H.P. generator. The piles, each with 11 cells are grouped in sections of four run in parallel; thus the current of 125 volts runs through four

[100] *Transactions of the American Electrochemical Society*, 1902, 1., 81.
[101] *Electrochemical Industry*, 1902, 1., 18.

[illegible] parallel. The plant, when run- [illegible] of lead per day.

[illegible] at East Helena

[illegible]

gated plunger *C*. The screw-shaft *A* with plunger *C* is firmly connected with the frame *RR*, which is suspended at *NN* from a traveling crane. The operation of the motor causes the cylinder *F* with bottom *G* to move up against the plunger. Thus the cylinder and bottom, the uprights moving along the guides *P*, and the motor with connecting gears, all move up and down together as a single piece. Supposing the cylinder to have been filled with a zinc-silver-lead crust and the motor started, the cylinder will rise, press the crust against the teeth *L* of the

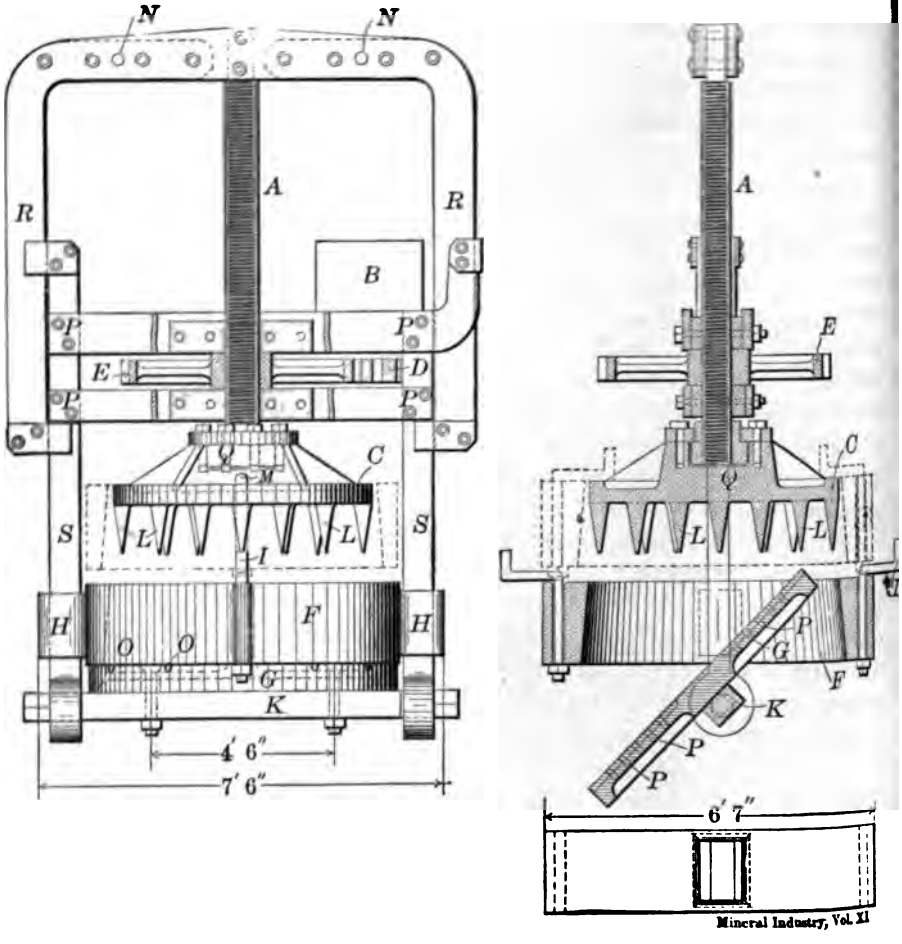


FIG. 5.—IMPROVED HOWARD ALLOY PRESS.

plunger. The teeth sink into the crust and facilitate the escape of the unalloyed lead through the perforations *P* of the bottom *G*. Reversing the motor causes the cylinder with the compressed cake to descend and leave the plunger which is connected with the base of screw-shaft (see *Q*) through collar and socket in such a manner that it can be turned. It is now given a slight turn, and the motor started for another compression, when the teeth will make a new series of holes, again aiding the escape of the unalloyed lead. By repeating these op

several times, a very dry zinc-silver-lead crust is obtained. When the
is over, the hooks *l* passing through the iron ring *F* are turned as
the dotted lines, to engage with the plunger. When the motor is now
the ring *F* remains suspended to the plunger while the cake of crust
follows the descending bottom. This is turned and the cake dumped
to a buggy. In order to facilitate the passing out of the cake of crust,
of the cylinder is flared downward. The advantages of the improved
that is common use to-day are, the use of the toothed plunger, the
of position after every single compression, which by repeated puncture-
ing of the mass facilitates the escape of the lead, and thus gives
the detached movable bottom which allows easy dumping of the
perforated condition of the crust which makes it easy to break into
for the retort.

Electrolytic Refining.—The electrolytic refining of zinc-silver alloy obtained at
in desilverizing argentiferous lead by the Rossler-Ekelmann modifi-
Parkes process.[1] The alloy anodes contain Ag 0.1 to 11.3%,
Pb 2 to 3%, Ni 0.5 to 1%, Fe 0.25%, Al 0.5%, Zn 0.3 to
sulphate in the electrolyte, the current is from 80 to 90 amperes
of cathode area at 1.2 to 1.5 volts, satisfactory cathode zinc is
with a current density of 80 amperes per sq. m. cathode area
(Ag 99 to 99.5%, Cu 0.1 to 0.3%, Pb 0.1 to 1.5%, difference Zn)
with sulphuric acid (to remove copper and zinc), washed, dried
added to the reducing furnace charge. The process has proved
especially as the works treating very low grade base bullion furnish
also to permit running the plant continuously.

[illegible]

[illegible]

$$SiO_2 + 4HF = H_2SiF_6 + 2H_2O$$

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Contact with the bus bars is made by means of small wells of quicksilver, copper pins being clamped to the anodes and soldered to the cathodes. The fall in potential between vats is 0·20 volt. A current of 14 amperes per sq. ft. of cathode area has been found to give the best results. In the process, copper, antimony, bismuth, arsenic, silver and gold remain more or less adherent to the anode, while zinc, iron, nickel and cobalt go into solution. Allowing 175 cu. ft. electrolyte for a daily output of 1 ton of lead, there will be only a small concentration of impurity at the end of a year's work. The slimes at Trail assay about 8,000 oz. silver-gold per ton, and are treated at the Seattle Smelting & Refining Works by boiling with sulphuric acid in the presence of air to remove the copper, drying, melting down in a magnesia lined reverberatory furnace provided with tuyeres, and refining. After parting, the silver is 999 fine; the gold 992.

Treatment of 2 kg. base bullion assaying Pb 98·766%, Ag 0·50%, Cu 0·31%, Sb 0·43% in an experimental way, using a current of 25 amperes per sq. ft. of cathode area gave refined lead; Pb 99·997%, Ag 0·0003%, Cu 0·0007%, Sb 0·0019%; and anode mud: Pb 9·0%, Ag 36·4%, Cu 25·1%, Sb 29·5%. Another test on 450 lb. of base bullion of the Compañia Metalurgica Mexicana (Cu 0·75%, Bi 1·22%, As 0·94%, Sb 0·68%, Ag 358·9 oz., Au 1·171 oz.) with a current of 10 amperes per sq. ft. of cathode area gave refined lead; Pb 99·9861%, Cu 0·0027%, Bi 0·0037%, As 0·0025%, Sb none, Ag 0·0010%, Au none, Fe 0.0022%, Zn 0·0018%. As one ampere deposits per hour 3·88 g. lead, 2,240 lb. will require 260,000 ampere-hours. At 10 amperes per sq. ft. of cathode area, the entire anode or cathode area per ton of daily output would be 1,080 sq. ft. With an electrode distance of 1·5 in., 135 cu. ft. electrolyte will be enclosed by the electrodes, and 175 cu. ft. may be taken as the entire quantity of solution that is necessary. A total of 260,000 amperes at 0·25 volts equals 87 E.H.P. hours of 100-H.P. hours at the engine shaft. Estimating that 1-H.P. hour requires 1·5 lb. coal, and allowing 60 lb. for casting anodes and refined lead, a ton of refined lead will require 210 lb. of coal, which, at $6 per ton, will give a fuel cost of 60c. per ton of base bullion.

MAGNESITE AND EPSOM SALT.

By [illegible]

[illegible]

the manufacture of magnesite bricks and other refractory products, an industry which at present uses magnesite imported from the Island of Eubœa, in Greece, and from Styria, in Austria.

The development of the iron and steel industry on the Pacific coast would give a strong impetus to the mining of magnesite and its manufacture into magnesia bricks and concrete for use as a basic lining to furnaces or converters, which treat phosphoric pig iron to make basic open-hearth or basic Bessemer steel.

The principal producing magnesite property during 1902 was near Porterville, Tulare County, where the mineral occurs in a series of vertical and flat veins up to 10 ft. in width, some of which outcrop boldly, having the wall rocks of serpentine and granite. A few veins have been traced on the surface for several thousand feet. A large quantity of mineral of exceptional purity has been disclosed by open cuts and a tunnel. A calcining plant of a capacity of 20 tons of finished product per day, has been completed at the mines, which are three miles from the railroad. The kiln is placed on the steep mountain side and the raw magnesite, broken to the required size at the mine above, is run down a long chute lined with sheet iron to the charging car without further handling. The calcined material after cooling is run directly into sacks, and is ready for shipment. Crude oil is used for fuel, and the mechanical equipment of the plant is modern in every respect. The calcining treatment, at a temperature of 2,500° F., occupies from three to three and one-half hours. The carbon dioxide gas which is expelled is allowed to escape into the air. Owing to the fact that during calcination magnesite loses from 48 to 52% of its weight, the cost of the calcined product at the kiln is stated to be from $12 to $14 per ton.

The production of crude magnesite is practically under the control of one firm which ships the entire output to two manufacturers of carbon dioxide gas for the production of the gas by calcination; the calcined product, which is essentially magnesium oxide or magnesia, is returned to the shipper, and is subsequently utilized by paper mill concerns in California and Oregon. The demand for calcined magnesite for this purpose in the West is limited, and only a small portion of the available supply is utilized—a trade condition which is reflected by the different unit values of the calcined product in various years considered in connection with the quantities produced. Thus in 1900 the supply amounted to 1,013 short tons, and the average value per ton was $15·70; in 1901 the output of 4,726 short tons far exceeded the demand and the average value decreased to $5·58 per ton; in 1902, when the supply reached the normal consumption of 1,050 short tons, the average value per ton rose to $15.

Imports.—The imports of crude and calcined magnesite during 1902—chiefly from Greece and Austria—amounted to 49,786 short tons ($373,928), as compared with 33,461 short tons in 1901. There was also a large importation of magnesite bricks, but no statistics of their quantity and value are available. It is thus seen that the United States furnishes a small proportion only of the total consumption.

The total quantity of magnesite consumed in the United States is approximated by adding together the domestic production and the importation, although in the latter case there is no distinction made between the crude and calcined

Epsom Salt in Wyoming.

By Wilbur C. Knight.

Epsomite occurs in Albany County, about 20 miles north of Rock River Station, on the Union Pacific Railroad. The deposits are situated upon a high plateau, about three miles north of Rock Creek, and lie in a huge, undrained depression that is deepest at its southern end, where it is about two miles wide, and lies 100 ft. or more below the level of the surrounding country. From this deepest portion a rather broad, shallow valley extends to the northwest for several miles and contains numerous deposits of sodium and magnesium salts, which have for a long time been tributary to the large epsomite deposit of about 90 acres in extent occupying the lowest portion of the basin. The prevailing formation is Red Beds (either Triassic or Permian), almost completely made up of red sandstones, which contain an abundance of gypsum near their base. The country is very arid, and the nearest palatable water is Rock Creek.

The deposits are often covered with water in early Spring or after a hard storm, which, however, soon evaporates. Near the northeastern quarter of the large deposit, which is the only portion that has been carefully examined, the epsomite occurs in a thick bed, containing in addition a good deal of foreign matter. Holes have been dug to a depth of 10 ft. in this salt, but the bottom has not been reached. While no accurate estimate has been made of the quantity of Epsom salt in this deposit, it is certainly very great and would furnish sufficient salts to supply the American trade for many years to come. From the surface of this deposit there have been taken some of the finest crystals of epsomite yet discovered.

The origin of the deposit, and those that are associated with it, has long been in doubt. In studying this problem I have ascertained that both epsomite and mirabilite (Glauber salt) have been derived from the decomposing sandstones, and have been transported by water to the natural depressions. Both the epsomite and mirabilite occur in the rocks, but on account of the greater solubility of the former, the soda salts are often precipitated in a depression, leaving the epsomite in solution. A sudden storm floods the deposit and carries the magnesium salts to a lower basin, if not to the lowest one. By this natural method of differentiation these salts have been separated, so that at the head of the valley the deposits are nearly pure mirabilite, while the main deposit is nearly pure epsomite. The composition of the various deposits is shown by the samples, which are averages taken from the various deposits and analyzed by Dr. Slosson, of the University of Wyoming. The large deposit, however, often has a thick covering of epsomite which is much purer than these samples.

Components.	Samples.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Na_2SO_4	95·46	94·54	50·90	47·74	39·18	25.61
NaCl	0·28	0·23	0·50	1·86	1·00	5·28
$MgSO_4$	4·26	5·29	48·60	50·16	59·82	70·11
$CaSO_4$	....	1·89	.....	.....	.....	.....

No. 1 of this series was taken from near the head of the gulch and the other from the intermediate points, and the last from the large deposit. The series shows quite wide gaps in the succession, which would be filled by taking more *samples from* the intervening beds.

MANGANESE

By D. H. Newland

The price of manganese ore is determined by the Carnegie Steel Co., according to the following schedule, which is based on ores containing not more than 8% SiO_2 and 0·1% P. Deductions are made of 15c. per ton for each 1% of SiO_2 in excess of 8%, and of 1c. per unit of manganese for each 0·02% P in excess of 0·1%. Ores delivered at the works of the company, at Pittsburg or Bessemer, Pa. Settlements are based on analysis of samples dried at 212°F.; the percentage of moisture in the samples as taken being deducted from the weight. Ores containing less than 40% Mn, or more than 10% SiO_2 or 0·15% P, are subject to acceptance or refusal at buyer's option.

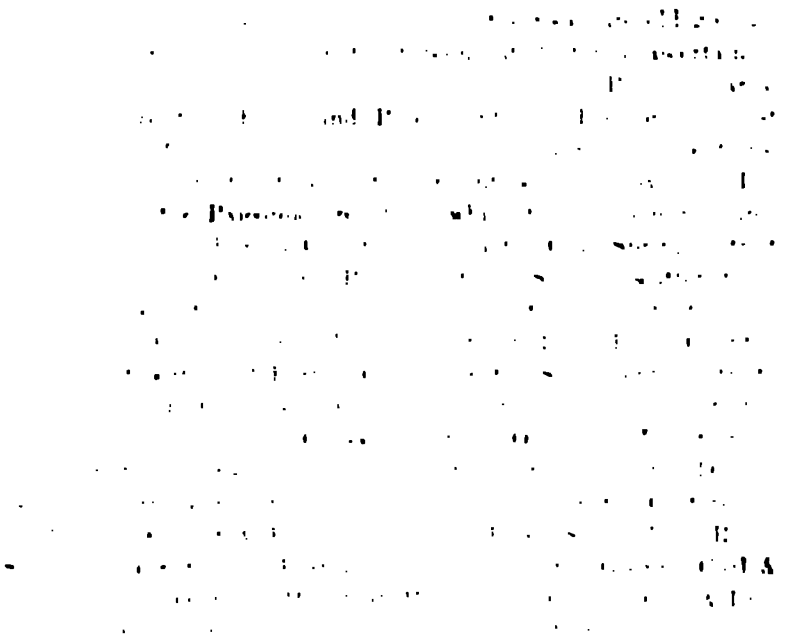
Tenor in Mn.	Price per Unit.		Tenor in Mn.	Price per Unit.	
%	Fe.	Mn.	%	Fe.	Mn.
Over 49.....	5c.	25c.	43 to 46.....	5c.	23c.
46 to 49.....	5c.	24c.	40 to 43.....	5c.	22c.

The imports of manganese ore during 1902 were 235,576 long tons, valued at $1,931,282, as compared with 165,722 long tons, valued at $1,486,573 in 1901.

The manufacture of ferromanganese by electrolysis has been proposed at works to be erected near Orlu in the French Pyrenees, where cheap water power is obtainable. It is planned to use the Simon process, by which the manganese oxide is dissolved in a bath of fluorspar and precipitated in the same manner as in the manufacture of aluminum. This method, it is stated, possesses the advantage over the usual smelting process in that the phosphorus present in the ore is partially volatilized, and hence lower-grade material can be used. Ferromanganese obtained in the experimental way by this process was found to possess the following composition: Mn, 83·50%; Fe, 8·74%; Si, 0·32%; C, 7·32%; P, 0·12%. It is thought that the cost of producing ferromanganese by this process would amount to about 204 fr. per metric ton, with an annual output of 20,000 tons.

Colorado.—The ores mined in this State consist of manganiferous iron ores which are used for the manufacture of ferromanganese and spiegeleisen and manganiferous silver ores utilized for flux by the silver-lead smelters. The output of ores of the former class in 1902 was valued at $8,400, containing on the average about 30% Mn and 23% Fe. The mines are situated around Leadville.

Georgia.—(By Thomas L. Watson.)—The mining of manganese ores in Georgia began in 1866, when 550 tons of ore are reported to have been mined in the Cartersville district. The manganese ores are distributed over the northern part, being limited to two geological areas—namely, the Paleozoic area, which includes the ten extreme northwest counties, and the crystalline area, which includes all the northern part except the ten northwest counties of the Paleozoic group. The Paleozoic area, constituting a part of the southern Appalachian valley province, is composed entirely of sedimentary rocks, which range in age from Cambrian to Carboniferous. The rocks include slates, shales, sandstones, quartzites and limestones. The topography of the region is the distinct ridge-valley type. The strata have been folded and faulted, and the resulting topographic features are largely dependent on the underlying structure. The crystalline area consists of crystalline rocks derived partly from original igneous masses and



a trace of manganese. Assays of the ore showed from 22 to 57% Mn and from 3 to 32% Fe. By hand cobbing to remove the limonite the average ore may be enriched so as to assay from 45 to 50% Mn. At the locality in Haywood County the ore occurs as float and in the superficial rocks. Most of the material is soft and friable, with a considerable percentage of limonite; the small proportion of hand ore carries about 50% Mn. Only limited development work has been done, and the value of this deposit, as well as of that in Wayne County, is not yet established.

Virginia.—The mine at Crimora was operated during 1902, and for a time produced about 50 tons of ore per day. The system of underground mining formerly employed here has been superseded by hydraulic methods, as described in THE MINERAL INDUSTRY, Vol. X.

WORLD'S PRODUCTION OF MANGANESE ORE. (*a*) (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Bosnia. (*b*)	Brazil. (*e*)	Canada.	Chile. (*d*)	Colombia.	Cuba	France.	Germany	Greece.	India.	Italy.
1897	10,043	28,372	5,344	16,054	14	23,528	8,382	.....	37,212	46,427	11,868	74,868	1,694
1898	14,219	16,440	5,320	26,417	45	20,851	11,176	*Nil.*	31,935	43,354	14,097	61,469	2,068
1899	10,484	12,120	5,270	65,000	279	40,981	10,160	*Nil.*	39,897	61,329	17,600	88,520	4,288
1900	14,550	10,820	7,939	108,244	27	25,715	(*c*)	21,973	28,992	59,204	8,050	132,767	6,014
1901	12,077	.....	6,346	100,414	399	18,480	.....	.....	22,304	56,691	14,166	135,307	2,181

Year.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	South Australia (*d*)	Spain.	Sweden.	Turkey	United Kingdom.	United States.
1897..	17,351	192	1,652	403	370,195	*Nil.*	100,566	2,749	.....	609	161,128
1898..	11,517	220	907	68	329,546	5	102,228	2,358	.....	235	190,787
1899..	11,340	137	2,049	747	659,301	102	104,974	2,622	49,468	422	145,548
1900..	15,228	166	1,971	77	(*c*)	*Nil.*	112,897	2,651	*d* 38,100	1,384	221,714
1901..	.....	208	904	221	.....	144	60,325	2,271	.....	1,673	649,016

(*a*) From official statistics, except for the United States and Colombia, for which direct reports have been received from the producers. (*b*) Includes Herzegovina. (*c*) Statistics not yet published. (*d*) Export returns. (*e*) Shipments as stated in British Diplomatic and Consular Reports, except for 1899, which are estimated.

Brazil.—Deposits of manganese ore are widely distributed in this country, and in places they are enormously rich. The principal mines are situated near Miguel Burnier, Queluz, San Goncalo and Piquiry in the State of Minas Geraes, near Corumbá in the State of Matto Grosso, and near Nazareth in the State of Bahia. In Minas Geraes the largest producers are the Usina Wigg, Sociedade Geral de Minas de Manganez, and the Société Anonyme des Mines de Manganèse de Ouro Preto. A new company, the Morro da Mina Co., was incorporated during 1902 to work the deposits at Queluz. The ores from the district of Miguel Burnier are high grade, carrying from 48 to 55% Mn and a very small percentage of phosphorus; those from Lafayette carry about 50% Mn and 0·12% P. The total exports of Brazil in 1902 were 143,320 metric tons.

Colombia.—The manganese industry of the Isthmus of Panama is described by E. G. Williams in a paper read before the American Institute of Mining Engineers, October, 1902. The ore-bearing region is situated on the Caribbean coast, extending from Puerto Bello easterly about 35 miles toward Point San Blas. Ore has been found in the interior at a maximum distance of about 10 miles from the coast. In general, the deposits occur within the drainage areas of the short streams that flow northward into the Caribbean Sea, although one

Cuba.—The deposits of manganese ore in Cuba are situated near the city o Santiago at the eastern end of the island. The first shipments in 1887 amounte to only 50 tons, but by 1890 they had increased to nearly 22,000 tons Fro 1898 to 1901 the Ponupo Mining & Transportation Co. was the only producer o manganese ore in this region. This mine, which in 1902 produced 33,0 tons of ore, lies in the center of an anticlinal fold and covers an area of abo 80 acres. The ore varies from high-grade material to a hard jasper, local called *bayate,* containing little manganese and occurring in irregular mass Often the ore is intimately veined or impregnated with jasper, and in su cases it is valueless, but usually the rocks may be separated after mining. Thr log-washers are used, and the tailings carry from 15 to 30% Mn. The mir give employment to 150 or more men at wages of $0·85 per day. The avera output is 2,000 tons per month, costing $2·25 per ton at the mine. The freig rate to Santiago is $39 per car of 30 tons, and the rate from Santiago to N York varies from $1·80 to $2 per ton. The character of the deposits at t Boston and Ysabellita mines is similar to that of the Ponupo mine. A lar quantity of ore has been extracted from the Boston mine, and operations ha been started recently at the Ysabellita mine. The latter has an aërial tramw connecting with the mill where the ore is to be treated by a jig process. Th are the only mines in operation at present, although it is possible that oth will be developed with the completion of the Cuba Central Railway. From t mode of occurrence it seems probable that the deposits now operated are not great extent.

France.—The ores mined include the carbonate, oxides and silicate of ma ganese. The deposits of Las Cabesses in the Department of Ariège suppli 3,500 metric tons of calcined carbonate in 1901, and the mines of Romanèc and Grand-Filon in Saône-et-Loire produced 9,600 tons of hydrous oxides. addition there was a production of 6,200 tons of manganese hydroxides and si cate from the mines of Louderville, Aderville and Ville-Aure in the Departme of Hautes Pyrénées.

India.—Manganese is extensively mined in the Vizagapatam district of Ma ras, about 500 miles north of the city of Madras and also near Kamptee, in t Nagpur district of the Central Provinces. In 1901 the former district pr duced 76,463 long tons of ore, and the latter 81,264 tons; while the districts Balaghat and Bhandara, in which developments were only recently beg produced 4,330 tons. The total exports from India during the same year w 133,170 tons.

Italy.—The production of manganese ore is limited to a few small mines the districts of Carrara, Iglesias and Florence. The district of Florence p duces also manganiferous iron ore, the output in 1901 being 24,290 tons, val at about $3 per ton.

Queensland.—The production of manganese in 1902 was 4,674 metric to valued at £16,989, as compared with 221 metric tons, valued at £795, in 19 In the Gladstone district, deposits at Mount Miller, Auckland Hill and E *Creek have* been worked at various times, but during 1902 operations w *limited to the* deposits at Mount Miller, which produced ore valued at £3

MICA.

By Henry Fisher.

The statistics of the production of sheet mica in 1902 are not yet available; the output during 1901, however, amounted to 360,060 lb., valued at $98,859. The mica imported into the United States during 1902, was 2,251,856 lb., valued at $466,332, 2,149,557 lb. ($419,362) being unmanufactured and 102,299 lb. ($46,970) being cut or trimmed.

The market for coarse and fine ground mica in New York, ruled at 3@4c. and 4@5c. per lb. respectively until the middle of September, when it dropped to 1·75@1·9c. and 0·87@2c., and remained there till the end of the year. The market for sheet mica did not vary throughout the year, and was as follows: 2×4 in., 30c.; 3×3 in., 80c.; 3×4 in., $1·50; 4×4 in., $2; 6×6 in., $3.

The General Electric Co., of Schenectady, N. Y., leased the plant of the Ottawa Porcelain Co., at Ottawa, and during 1902 employed 300 persons in trimming and cutting mica, most of it to be used in the manufacture of micanite. During 1902, only mica mined in Ontario was used, but the company has secured control of several important mines in Quebec, and will operate them in 1903.

A patent[1] has been granted to H. C. Mitchell for the manufacture of flake mica which consists in passing the sheet mica through bending rolls to loosen it, and then subjecting it to a blast of air, whereby the lighter flakes are blown into one chamber, and the plates not disintegrated are collected in a second chamber: the treatment being repeated a second time.

State.	1900.				1901.			
	Sheet.		Scrap.		Sheet.		Scrap.	
	Pounds	Value.	Short Tons.	Value.	Pounds	Value.	Short Tons.	Value.
New Hampshire	25,241	$11,358	2,405	$21,645	65,800	(a)	250	(a)
North Carolina and Virginia	34,500	24,150	2,790	19,530	266,160	.....	1,775	.....
South Dakota	65,000	45,000	222	1,554	25,000	.....	.....	.....
Other States	2,500	2,000	20	160	3,100	.....	146	.....
Totals	127,241	$82,508	5,417	$42,889	360,060	$98,859	2,171	$19,719

(a) Not given.

California.—The Barton Mica mines on Piru and Lockwood creeks in Ventura County, which were discovered in 1901, had 10 men at work in 1902, and up to

[1] English Patent No. 4,969. March 8, 1901.

[illegible] year had made two shipments of mica to San Francisco, where it [illegible]. A mill is being erected on the property. These deposits covering [illegible] are 20 miles from Bakersfield. At the Gypsy deposit considerable [illegible] occurs, but most of the product is more suitable for grinding. A [illegible] is being erected.

The Estate Mining Co. during 1902 developed four claims on Bear [illegible] Texas Gulch, Custer county. The vein is reported to be 30 ft. wide, [illegible] vary in size from 2 × 2 in. to 10 × 12 in. In the early part of [illegible] was 2 tons per week.

[illegible] The principal deposits of mica are in Mitchell, Yancey, [illegible] and Mason counties, over 100 mines occurring in these five [illegible]. The mica is found in pegmatite dikes, and constitutes from 1 to 10% [illegible]. Many other minerals are found with the mica, and some of them [illegible] in sufficient quantity to be of commercial value.

[illegible] The Black Hills Porcelain Clay & Marble Co. operated its [illegible] in Custer county throughout 1902. In the early part of 1903, the [illegible] 20 tons of mica per month, obtaining $30 per ton, f. o. b. [illegible]. The Custer mica mine owned by the Chicago Mica Co. covers 40 acres [illegible]. The mine is shipping regularly two carloads of mica to the company's [illegible] in Indiana.

According to H. Anderson Scott, mica occurs in workable quantities [illegible] of Bahia and Minas Geraes. In the State of Minas Geraes, [illegible] pegmatite veins, lenses or dikes in metamorphic schists [illegible] of Santa Luzia de Carangola, the veins running parallel to the [illegible] Mountains. The veins are generally altered to kaolin, [illegible]. [illegible] have supplied [illegible] Terra Branca Co. Several Scraps [illegible], [illegible]. About [illegible] have been produced, a large proportion of which has been used for lamp [illegible] has been shipped to the United States and London. The [illegible] Scraps [illegible] to 20 tons. The [illegible] the mica [illegible] of the veins is mostly [illegible] from the effects of the [illegible] of the veins varies from [illegible] about 2 [illegible] are carried [illegible] Santa Luzia [illegible] [illegible] was transported [illegible] about [illegible] per ton. [illegible] freight charges [illegible] freight [illegible]

There was a large [illegible] mica [illegible] the [illegible] Co. [illegible] [illegible] [illegible]

edges trimmed, 111,385 lb., ($42,268); edges untrimmed, 345,323 lb. ($75,167); ground, 229 lb. ($20). The shipments to the United States during the fiscal year amounted to 868,645 lb., valued at $186,400; to the United Kingdom, 115,388 lb., valued at $53,001, the remainder going to France, Germany and Mexico. The phlogopite and biotite varieties are mined in the provinces of Ontario and Quebec, in the district about Ottawa, while transparent muscovite of excellent quality occurs at Tête Jaune Cache and Canoe River in Northern British Columbia. Although sheets of mica of over a foot in length are not uncommon, the deposits in British Columbia are too far distant from railroad communication to be worked at present. In Ontario there are mills at Sydenham, Ottawa, Kingston and Perth, which split the blocks of mica and "thumb-trim" it. A mill at Gananoque grinds the mica into scrap. In Quebec, as stated by J. Obalski, the mica market was very quiet in 1902, and while the demand was steady, the price for the larger sizes declined. Only a few of the more important mines, including those of Messrs. Blackburn Bros., Wallingford Bros., and Fortin & Gravel were operated in 1902. Messrs. Fortin & Gravel employ five men at their mine in Hull. The mica is sized, trimmed and packed at Hull, five women being employed at this work. Some of the smaller companies operating in 1902, were Allan Gold Reef, in Derry; Glen Almond, in Portland East; Vavassour, in Hull; and F. N. Webster at the Cascades in the Gatineau. The thumb-trimmed mica shipped from Quebec in 1902, amounting to about one-third of the total production, was in detail: 64,463 lb. of 1×3 in. mica, ($7,364); 27,861 lb. of 2×3 in. ($7,201); 27,296 lb. of 2×4 in. ($10,756); 11,772 lb. of 3×5 in. ($7,578); 890 lb. of 4×6 in. ($820), and 540 lb. of 5×7 in. ($585), aggregating 132,822 lb. of mica, valued at $34,304.

India.—Mica which is worked in a primitive manner in Bengal and Madras was produced to the extent of 996 tons in 1902, the exports amounting to 815 tons. In 1902, in the districts of Nellore, North Arcot, and Nilgris, in the Province of Madras, there were 69 mines in operation, employing 2,965 persons, and producing 228 long tons of mica, and in the district of Hazaribagh in the Province of Bengal, there were 61 mines employing 6,254 persons, and producing 768 long tons of mica, 628 tons being mined by one company. The Government annually leases the land to the highest bidder. The mica occurs in veins of coarse pegmatite and native methods are used to mine it. During the rains, the surface is prospected and shoots and patches of mica are marked when found, to be worked during the cold and hot weather. Machinery is not used, all the work being done by hand labor. Women are employed, who, seated on ladders, pass back and forth vessels filled with water and baskets with mica.

THE MICA INDUSTRY OF NEW HAMPSHIRE DURING 1902.

BY ALBERT J. HOSKINS.

THE mica industry of New Hampshire has not shown any advance during the past year. There were only two mines operated, one controlled by the Davis *Mica Co.* and the other by the Henri Picard Co.; the mines of both companies are situated in Alstead, Cheshire County. The Davis Mica Co. employ eight

[illegible] about 1 ton per day including scrap mica. The Henry Pecard [illegible] 12 tons per day, the daily output averaging a little more than 1 ton. [illegible] prospects have been opened up in Grafton and Sullivan counties, which, [illegible] do not show enough mica to warrant the investment of capital for [illegible] mica after being blasted out undergoes a hand dressing (rifting) in which [illegible] the refuse or cracked and stained mica is split off. The remaining [illegible] of free-splitting mica is trimmed and assorted to four grades or sizes. [illegible] grade measures either 4×6 in. or 6×8 in., and sometimes larger; No. 2 [illegible] ranges from 3×4 in. to 4×6 in., No. 3 grade averages from 2×4 in. to 3×4 [illegible] No. 4 grade averages from 1 in. to 2×4 in. Mica of No. 4 grade is known [illegible] as rough trimmed mica. The waste or trimmings are sold to the mills [illegible] ding purposes.

[illegible] Pecard mills ground all the scrap mica taken from the mines in the [illegible] The scrap mica is ground into grades ranging from 10 to 200 mesh. The coarser grades, ranging from 10 to 60 mesh, are most in demand at [illegible] due to the fact that they are used extensively in repairing roofing, [illegible] covering and insulating compounds. The finer grades are utilized by [illegible] manufacturers for decorating purposes, also as an adulterant of rubber [illegible] manufacture of paint, lubricating oils and axle grease. The prices ob- [illegible] ground mica in carload lots at place of production are from $30 to $100 [illegible] according to quality and fineness.

[illegible] beginning of 1902 there was only a small quantity of scrap mica in the [illegible] and the prices showed an upward tendency, ranging from $25 to $30 [illegible]

A considerable quantity of scrap mica is used in the manufacture of [illegible] [illegible] [illegible]

THE MANUFACTURE OF MINERAL WOOL.

By Edwin C. Eckel.

Mineral wool is the product obtained by forcing a jet of steam or air against a stream of molten slag or molten rock. The effect of this proceeding is to scatter the molten material, small spherules being blown out from the main stream, each spherule, comet-like, carrying behind it a thread of the material. The fluidity and composition of the molten mass, and the pressure, size and direction of the jet of steam or air, are so manipulated as to give the greatest proportion of threads or fiber to spherules as the spherules are commercially unavailable and must be separated by mechanical means from the fibers if present in too great quantity. Usually, however, a satisfactory separation is obtained by changes in the direction or pressure of the steam, the spherules falling first while the lighter fibers are carried further into settling chambers.

The resulting product is a non-conductor of heat and sound, and is therefore largely used for pipe covering, safe linings, cold storage plants, partitions, etc. It is marketed under many names—mineral wool, slag wool, rock wool, silica fiber, silicate cotton, etc. The reasons for this great variation in nomenclature are given later in the article.

Growth of the Industry.—Blast-furnace slag was first manufactured into mineral wool about 30 years ago in Germany, and was shortly afterward taken up in England and in the United States. The first American plant was located at the Greenwood iron furnace, in Orange County, N. Y., the manufacture of mineral wool being taken up there on a small scale in 1875, under the management of Mr. Parrott. Later, an incorporated company acquired the slag wool plant, and under the management of Mr. A. D. Elbers the output was materially increased. In 1882 the product was 1,085 tons of "ordinary" grade, worth $27,125; and 92 tons of "extra," worth $5,520; a total of 1,177 tons, valued at $32,645. During the first six months of 1883, the product was 65 tons of "ordinary," worth $13,100; and 47 tons of "extra," worth $2,820, a total for the half-year of 702 tons, worth $15,920. From these figures it will be seen that the industry had established itself in this country within eight years, for the total annual produc-

tacks the iron pipes. Slag wool coverings on pipes which are buried underground may also be attacked by organic acids.

The impression made on engineers by the discussion of these facts, and the consequent falling off in the utilization of mineral wool, led manufacturers to attempt the preparation of a material which would be free from the above-cited objections. These attempts took two very different lines, which will be separately discussed under the headings of (1) rock wool, and (2) desulphurized slag wool.

Rock Wool.—Obviously, one way out of the difficulty was to abandon the use of slags, which almost inevitably contain appreciable amounts of sulphur; and to use in place of them other materials, of about the same bulk composition, but free from sulphur. A glance at the table of analyses of various mineral wools will show that the percentages of their principal constituents fall within the following limits: Silica, from 35·92 to 48·62%; aluminum and iron oxide, from 8·48 to 22·17%; lime, from 22·96 to 41·86%, and magnesia, from 2·98 to 19·82%.

It is possible to find natural rocks which will analyze after melting within these limits; but deposits of such favorable materials are not common, nor are they always well situated with regard to transporation facilities and market. In general, therefore, the rock-wool manufacturer is satisfied with a rock which can be cheaply extracted, and is well located, so long as it approximates the desired composition, which is subsequently obtained by adding to the rock a suitable quantity of sand, clay, or pure limestone, according as the main rock is deficient in silica only, in both silica and alumina, or in lime.

The methods of manufacture at the typical "rock wool" plant of the Crystal Chemical Works, Alexandria, Ind., is as follows: The material utilized in the manufacture of mineral wool is a highly siliceous limestone, analyzing: SiO_2, 26%; Al_2O_3, 12·02%; Fe_2O_3, 1·78%; $CaCO_3$, 37·92%; $MgCO_3$, 17·38%; H_2O, 4·90%. This rock forms a massive bed, 5 ft. thick, in the Niagara (Upper Silurian) formation which outcrops near Alexandria. The rock is blasted out in large fragments, drawn by team to the mill, which is near the quarry, and heated to a red heat, which disintegrates it. When sufficiently disintegrated it is dumped from the furnace, which has a drop bottom, and a new charge introduced. The disintegrated rock is then charged into the melting furnace or cupola.

When operations at the plant were started, a cheap and apparently permanent supply of natural gas was obtainable. The freedom of this fuel from sulphur made it an ideal source of heat for mineral wool manufacture. During this early period the disintegrated rock was melted in a large reverberatory furnace, with 150 sq. ft. melting surface which delivered 8 tons per 24 hours. Two men operated both furnaces and the boiler. The furnace bottom was formed of fire clay tile supported by six 1-in. pipes laid horizontally, having a space for air circulation below the pipes, which prevented the molten charge from escaping through the bottom. The furnace was fired at one end with natural gas, introduced through a specially constructed burner, and the waste gases passed up the stack at the other end. Attempts were made to utilize the waste heat either in the preliminary heating of the rock, or under the boiler, but with little success owing to the choking of the flues with the fine dust carried from the charge

the SO_2 and H_2O being carried off by the blast. In the experimental working of this process at a slag wool plant, the addition of 9% gypsum gave a slag wool carrying only 0·02% of sulphur. Elbers states in regard to manufacturing details, that "blast-furnace slag can be remelted with about the same amount of fuel, weight for weight, as foundry pig iron; but the yield is only 10% as large, i.e., from 750 to 900 lb. per hour from a 42-in. cupola, with a blast pressure of from 2 to 4 oz. per sq. in. in the air pipe. A heat lasts from 12 to 20 hours, during this time the melt flows out continuously. The stream of the outflow should not exceed 0·75 to 1 in. in diameter, chiefly for the reason that equally good slag wool cannot be made from a stream of greater volume by proportionately increasing the size and force of the steam jet. The pressure of the steam should not exceed from 80 to 90 lb. per sq. in. On account of these various conditions a cupola 48 in. in diameter (inside of lining) is not likely to make more wool than a 42-in. one, while it will cost more for fuel; and it is likely that a 36- or 38-in. cupola will make as much wool (and of better quality) as either of the larger sizes. Cupolas smaller than 36-in. diameter are not so convenient for making inside repairs, which are needed after each melting, and do not give as long heats as are expedient. A well-conditioned plant of three cupolas should be able to turn out two carloads of mineral wool of 24,000 lb. each per day; but that is the maximum."

Physical Properties.—The appearance of mineral wool, under the microscope, is described[3] as follows:—

The sudden and violent explosive action by which the fibers and bulbs are formed would lead us to expect little regularity in their markings; but a considerable number exhibit a very beautiful and symmetrical ornamentation. The fibers vary in thickness from that of common spun glass to an extreme tenuity represented by fractions of a thousandth of an inch. The bulbs may generally be described as solid bodies containing more or less numerous vesicles or hollows. The more solid ones are transparent, or show iridescence. Many of the fibers are split, and occasionally several of them will be attached to the same bulb. When the fibers are crowded together they will form interstices of angular shape, so that free motion of the incased air is impossible, in consequence of which the material makes a poor conductor of heat. By calculation it is found that the "ordinary" and "extra" grades of slag wool contain respectively 88 and 93% of their volumes of air. This air circulates with such difficulty that the passage of heat is retarded, while the transmission of sound is prevented by the inelasticity or want of solidity of the material.

It is stated[4] that in ordinary practice a slag, weighing 192 lb. per cu. ft., will give 20% of "extra-grade" wool, weighing 14 lb. per cu. ft., and consisting of threads or fibers only, representing that portion of the material which has been blown entirely free from the "shot" or spherules. The remaining 80% will be of "ordinary" grade, weighing 24 lb. per cu. ft., and containing a considerable proportion of "shot" intermixed with the fibers.

Numerous experiments have been carried out to determine the relative con-

[3] *Mineral Resources, U. S. Geological Survey*, 1892, p. 162.
[4] *Ibid.*, 1892, p. 161.

[illegible] covering materials. The papers describing these tests are cited in the accompanying bibliography, and a few of the results [illegible]

data given in the following table have been selected from the results of [illegible] and from tests carried out by a firm manufacturing [illegible]. The results have been recalculated, when necessary, to permit the [illegible] power of mineral wool to be taken as unity.

HEAT CONDUCTING POWER OF VARIOUS MATERIALS

Materials	Authority			
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]

ANALYSES OF MINERAL WOOLS.

Components.	Slag Wool.	Slag Wool. (?)	Slag Wool. (?)	Rock Wool. (?)	Rock Wool.
	(1)	(2)	(3)	(4)	(5)
SiO_2	38·97	43·48	48 62	35·92	37·5
Al_2O_3	7·84	11·95	9·20	22·17	20·0
Fe_2O_3, FeO	0·64				
CaO	26 56	22·96	24·10	41·86	30·6
MgO	19·82	18·24	17·26	2·98	11·8
K_2O	0·19				
Na_2O	1·75				
S	2·46	(a) 4·67	(a) 1·75		
H_2O	1·08			0·07	

(a) Given in original as SO_3, which is probably erroneous. (1) *Transactions of the American Society of Mechanical Engineers*, Vol. III., p. 250, 1882. (2) *Ibid.*, Vol. XVI., p. 841, 1895. (3) *Ibid.*, Vol. XVI., p. 841, 1895. (4) *Ibid.*, Vol. XVI., p. 841, 1895. (5) *Manufacturers' Circular*, 1901.

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Anon. Utilization of blast-furnace slag. *Mineral Resources of the United States for 1882*, p. 161-164. 1883.

MOLYBDENUM

lead, 4·14 oz. gold, and 1·2 oz. silver per ton. Experiments were carried out by Mr. Wells for the purpose of finding suitable methods for concentrating the Canadian ores. On a sample containing 50% pyrrhotite, 10% pyrite, and 6·5% molybdenite in a gangue of calcite, biotite, quartz and pyroxene, good results were obtained by crushing in a jaw crusher, hand picking of the large flakes of molybdenite, recrushing in rolls set to 0·2-in. space, and successive sizings in screens from 0·3-in. to 0·05-in. mesh. The oversize from the screens which consisted of molybdenite, mica and rock was treated on a Wilfley table and yielded a commercial product. The Hartz jig was not adapted for concentrating this ore, but good results were obtained with the Wetherill magnetic separator, although, owing to the high current and slow speed necessary, it is doubtful if this separation can be done on a practical basis. Treatment by a modified form of the Elmore process was only partially successful, as the large particles of molybdenite were not affected by the oil. Another sample consisting of quartz and feldspar with 2·5% molybdenite, was crushed and sized, but gave no clean ore on any of the screens. The whole sample was then ground to pass a 0·05-in. screen and concentrated on a Wilfley table, the final concentration being effected by the oil process. The experiments carried out by Mr. Wells showed that no standard method can be adopted for concentrating molybdenum ores. Separate mill tests are required to determine the proper treatment in each case.

Analytical Determination of Molybdenum.—G. Auchy[1] gives the following method for the rapid determination of molybdenum contained in steel: 0·8 g. of drillings are placed in a covered porcelain dish and treated with 15 c.c. dilute HNO_3, 10 c.c. concentrated HCl, and 3 c.c. concentrated H_2SO_4, and boiled to dense fumes of SO_3. The cover also must be thoroughly dried. The residue is then boiled with 50 c.c. H_2O, cooled and carefully poured into 100 c.c. NaOH solution (1 lb. NaOH in 2,100 c.c. H_2O) in an 8-oz. Erlenmeyer flask, provided with a file mark at 200 c.c. The liquid is diluted to the mark, shaken well and the precipitate allowed to settle, filtered through a dry filter into a 100 c.c. measuring flask. The filtered solution is placed in a beaker, and after adding 15 c.c. strong H_2SO_4 is reduced and titrated.

Another method for the rapid determination of molybdenum in ores, which has given satisfactory results, is to fuse the ore with Na_2O_2 in a nickel crucible, cool, dissolve the product in H_2SO_4, neutralize the solution with NH_4OH, which precipitates the iron present, filter, acidulate filtrate with H_2SO_4 and pass through a column of metallic zinc (Jones reductor) before the final titration with potassium permanganate.

E. Pozzi-Escot[2] states that molybdenum salts produce fast shades on leather, similar to the action of titanium salts. Molybdenum tannate, which has a great affinity for animal fiber, is naturally of a deep yellow color, but a large variety of shades may be obtained by using it in connection with logwood extracts.

[1] *Iron Age*, Vol. LXX., No. 21, Nov. 20, 1902.

[2] *Comptes rendus*, CXXXV., 1902, 880; *Journal of the Society of Chemical Industry*, Dec. 31, 1902, 1533.

MONAZITE.

By Henry Fisher

to be evolved. The crucible is then heated 15 min. longer, and the fused mass is dissolved in hot H_2O acidified with HCl, the insoluble portion filtered off, boiled with concentrated HCl, diluted and filtered. The filtrate is nearly neutralized with NH_4OH, boiled, from 3 to 5 g. of $(NH_4)_2C_2O_4$ are added, and the solution is vigorously stirred. It is allowed to stand over night, and the thorium precipitate is filtered off, washed and transferred to a porcelain dish, the filter paper being washed thoroughly with hot concentrated HNO_3. The solution in the dish is then evaporated to dryness on a water-bath, a few c.c. of concentrated HNO_3 are added, then 20 c.c. of fuming HNO_3, and the liquid evaporated again to dryness. H_2O is added and the solution is evaporated to remove free acid diluted, filtered, brought up to 100 c.c. in volume, NH_4NO_3 added, and the thorium precipitated by H_2O_2 at 60° to 80°C. The precipitate is filtered, ignited to ThO_2 and weighed.

A new method[2] for the separation of thorium from cerium, lanthanum and didymium and its application to the analysis of monazite has been proposed by F. L. Metzger, as follows: 1 g. of the finely powdered sand is repeatedly evaporated to dryness with concentrated H_2SO_4. The mass is added slowly to 200 c.c. of ice-cold H_2O, stirring constantly, digested for several hours, the residue filtered off and washed. The filtrate is nearly neutralized with dilute NH_4OH(1: 20) and 50 c.c. of a cold saturated solution of $(NH_4)_2C_2O_4$ added. The precipitate is filtered, washed and boiled with 25 c.c. strong KOH solution, the solution diluted, and the precipitate filtered, washed, and dissolved in dilute HNO_3(1: 1), evaporated to dryness, dissolved in 50 c.c. H_2O, and diluted with H_2O and alcohol, until the solution has a volume of 200 c.c. and contains 40% alcohol; 20 to 25 c.c. of a 1% solution of fumaric acid are then added, and the whole boiled. The precipitate is filtered off hot, washed with hot 40% alcohol, re-dissolved in 25 c.c. hot dilute HCl (1: 1) and again evaporated to dryness. The residue is dissolved in 50 c.c. H_2O, alcohol and H_2O are added as before, and 10 c.c. fumaric acid, boiled, the precipitate filtered off, washed with hot 40% alcohol, ignited wet in a platinum crucible and weighed as ThO_2.

[2] *Journal of American Chemical Society*, 1902, 24, pp. 901-917; and abstract in the *Journal of Society of Chemical Industry*, Nov. 29, 1902, p. 1415.

NATURAL GAS INDUSTRY OF THE UNITED STATES DURING 1902

By W. H. Hamm.

rock pressure have been found at various points, extending from the extreme northern portion of Allen County southward nearly 100 miles into Indian Territory. Probably the largest development thus far made is near Iola, Kan. As yet, no satisfactory market for the fuel has been obtained, as there are no large cities in that vicinity, although many manufacturing and smelting plants have located in the Territory, attracted by the prospects of cheap fuel.

Ohio.—The vast Trenton limestone reservoir covering nearly all of western Ohio is so exhausted that but little gas is obtained, except by reducing the line pressure at the mouth of the well by pumping. Large quantities are thus produced, however, and if the present rate of depletion is continued it will result in the practical abandonment of the field within two or three years. Already many towns and cities formerly supplied from this reservoir are arranging to draw their supply from the West Virginia fields. The output from the Clinton limestone, in central and eastern Ohio, has increased. The old Sugar Grove field is depleting quite rapidly; while pumps are not necessary to secure a production, the rock pressure being from 150 to 200 lb., still they are almost universally used to increase the output. Several of the largest pumping plants, containing the most modern types of machinery, are at work in this field. During the year the Licking County field, about 30 miles north of the Sugar Grove pool and in the same formation, has been rapidly developed, and gives fair promise of rivaling the latter reservoir in productiveness. Companies which formerly drew their supply from the Sugar Grove field are taking a larger and larger supply from the new territory, and at the same time are extending large pipe systems southward to connect with huge feeders from the West Virginia fields.

Pennsylvania.—In Pennsylvania, the most important development of 1902 was in the Speechly sand of Armstrong County. This sand was formerly productive of oil and gas in Warren and Forest counties, and as early as the winter of 1894-5 a well was drilled to this formation near Brady's Bend, Armstrong County. But it has been within the past two years, and for the most part in 1902, that the southern extension has been explored. The stratum lies from 600 to 700 ft. below the Butler-Venango group of sands, and is found quite generally where explorations have been made throughout Armstrong and the eastern half of Butler counties and even southwest in Beaver County. The sand is only occasionally productive, and most of the wells have been small, averaging, at the beginning, approximately 750,000 cu. ft. daily, open flow measure, but falling to one-half this amount after a few months' use. In September, 1902, a well was drilled, however, near Worthington, Armstrong County, by the Philips Gas Co., which was capable of producing about 30,000,000 cu. ft. per day, probably the largest well ever drilled north of Pittsburg. Since then several wells of 5,000,000 cu. ft. capacity have been drilled in the vicinity of Pine and Mahoning creeks, east of the Allegheny River, in the extreme northern portion of Armstrong County. The rock pressure of the Speechly gas wells is about 800 lb. per sq. in. In the Bradford gas and oil field of McKean, Elk and Forest counties, several pools have been discovered in a formation from 200 to 300 ft. below previous productive measures, which show rock pressures of 1,200 lb.

West Virginia.—In West Virginia, the promise of the most extensive deposits

NICKEL AND COBALT.

By Joseph Struthers and D. H. Newland.

Prior to the year 1902, a portion of the total production of metallic nick and cobalt oxide in the United States was obtained as by-products in the treat ment of lead ores from Mine La Motte, Mo. In 1902, however, there was n production of these substances from domestic ores, as compared with 6,700 l of nickel and 13,360 lb. of cobalt oxide from this source in 1901. The cessatio of the manufacture of these products from domestic ores may be attributed t the recent combination of the principal companies employed in this industry whereby the final products are obtained from imported ores and matte at a lesse cost.

During 1902 the production in the United States of nickel as metal, oxid and sulphide from foreign ores and matte, aggregated 10,391,478 lb., as com pared with 8,664,614 lb. in 1901, making the total production of nickel from all sources to be 10,391,478 lb. during 1902, as compared with 8,671,314 lb. in 1901. The production of cobalt oxide from foreign ores and matte during 1902, amounted to 17,140 lb. valued at $38,736, as compared with 13,360 lb. from both foreign and domestic ores and matte during 1901.

UNITED STATES PRODUCTION, IMPORTS AND EXPORTS OF NICKEL.

Year.	Production.						Imports. (b)		Exports. (c)	
	From Domestic Ore		From Foreign Ore.							
	Metallic.		Ni in Sulphide, Oxide, etc. (a)		Metallic.					
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Long Tons.	Value	Pounds.	Valu
1898.....	11,145	$3,845	3,516,427	$1,213,167	3,611,357	$1,245,918	17,619	$1,020,982	5,657,618	$1,5
1899.....	22,500	8,156	3,003,122	1,088,632	5,045 221	1,828,898	19,687	1,101,999	5,004,377	1,15
1900.....	9,715	4,534	3,605,138	1,682,520	4,107,982	1,915,198	25,670	1,183,884	5,869,906	1,3
1901.....	6,700	3,551	4,653,337	2,168,455	4,011,277	1,869,255	52,111	1,637,166	5,869,655	1,5
1902.....	*Nil.*	*Nil.*	(d)	(d)	(d)	(d)	14,817	1,156,872	3,238,607	9

(a) The nickel reported as in oxide is now mostly converted into metal before consumption. (b) Ore matte. (c) Comprises domestic nickel, nickel oxide, and matte. (d) Statistics not available.

UNITED STATES PRODUCTION FROM DOMESTIC AND FOREIGN ORES AND MATTE AND IMPORTS OF COBALT OXIDE.

Year.	Production	Imports.		Year.	Production	Imports.	
	Pounds.	Pounds.	Value.		Pounds.	Pounds.	Valu
1897.....	19,300	24,771	$34,773	1900.....	12,270	54,073	$98,6
1898.....	9,640	33,731	49,245	1901.....	13,360	71,969	134,9
1899.....	10,200	46,791	68,847	1902.....	17,140	79,984	151,1

ating for nickel ores and exploitation of known deposits of unproved ue continued during 1912, but very little information has been made Most of the deposits are of very low grade and the development work there has not been of sufficient magnitude to be of interest. The chief e are in Arizona, Idaho, Nevada, North Carolina, Oregon and Wyoming. n 1911 the discovery of nickeliferous ore was reported near Wellington, County, Utah.

The market for nickel held steady throughout the year, being firmly so far as the United States is concerned, by the trust. The prices in ton and larger lots at New York were 40@45c. per lb., according to terms of order. For smaller lots as high as 60c. per lb. was quoted. noted that the market prices do not reflect the actual terms obtaining in transactions, as large sales are commonly made at much lower prices n quoted.

nd annual report of the International Nickel Co., which was formed 1902 to take over the properties owned by the Canadian Copper Co., d Copper Co., the Anglo-American Iron Co., the Vermilion Mining American Nickel Works, the Nickel Corporation, Ltd., and the Societe Caledonienne was submitted on March 31, 1913, for all companies except ept named. In its report the company places a valuation on its proper- ading the investments in stocks of the Nickel Corporation and the Caledonienne of $[illegible], and this sum, less $2,185,402, ing the surplus of the cost to the former at date of transfer, is carried et of the company. In addition the assets include £200,000 of debenture st of the Rio copper mine, valued at $[illegible], advances to constituent s of $[illegible], and current assets including investments, accounts and s on hand, etc., of $[illegible], making a total of $[illegible]. Among ties of the company are a capital stock of $[illegible] divided equally ion and preferred, bonded debt of $[illegible], current liabilities of s and a surplus account of $[illegible]. The year's earnings are stated s, which less administrative and other expenses of $[illegible] gave a of $[illegible]. The company further states that the various manu- erties have been found to be in a very poor condition, most of the ing and exploration of [illegible]. During the year the com- was expended for repairs at the works of the Canadian Copper Co and Copper Co. and the Orford Nickel Works. It is intended to the plants and to bring [illegible] to the highest standard of econ- and economic efficiency. At the works of the Canadian Copper Co. Rio two calcining furnaces [illegible] and the other 7 ovens re removed, each 40 ft. in length, and in their stead a new rotary ace was erected and put in operation in [illegible]. The construction new roasting plant at the works of the Canadian Copper Co. on Clarke's also was [illegible]. It is estimated that when [illegible] will be saving of from [illegible] per year.

THE WORLD'S PRODUCTION OF NICKEL. (METRIC TONS.)

Year.	From New Caledonian Ores.					Canada. (b)	Norway.	United States.		World's Total.
	Prussia.	France.	England	United States.	Total.			Domestic	Imported	
1898.....	1,108	1,540	960	.....	3,608	2,503	*Nil.*	5	3,284	6,116
1899.....	1,105	1,740	1,000	.....	3,845	2,605	(a)	10	3,651	6,460
1900.....	1,376	1,700	1,600	(d)	4,676	3,212	(a)	4	3,499	7,892
1901.....	1,660	1,800	(a)	1,796	6,202	4,168	(c) 27	3	3,643	10,373
1902.....	(a)	(a)	(d)	(d)	(d)	4,850	(d)	*Nil.*	4,714	.....

(a) Individual statistics not yet reported. (b) Nickel in ore and matte, nearly all the Canadian nickel is fined in the United States. (c) Nickel in Norwegian ore, included in U. S. production from imported or d) Statistics not available.

NOTE.—The figures for France and Prussia are from official reports; the amount credited to England l been obtained by deducting the output in France from the combined output of the French and English wo as given by the *Metallurgischegesellschaft, A. G.*, except in 1899, when the English production was repor separately. The actual output of all English works is somewhat greater than the above amounts as a li Canadian ore is smelted there. The Prussian figures include a small amount of nickel of domestic origin. T Canadian figures are those of the Geological Survey of the Dominion. The world's total has been arrived by adding the production from New Caledonian ores, the output of Canada and Norway, and the domestic p duction of the United States. In 1899, however, the total represents the total output in the United States the production from New Caledonia ores, since the imports into this country were not derived from Can alone.

Austria.—The nickel mines of Austrian Silesia were described by Illner the *Zeitschrift fuer das Berg-, Huetten-und Salinenwesen,* No. IV., p. 816, 19 The mines are situated at Kosemitz, Züsendorf and Gläsendorf, a short distan north of Frankenstein. Geologically the ore, which contains from 0·5 to 3% N is usually associated with a very siliceous rock called "red" rock, filling fissu in serpentine. Occasionally the veins are of talcose nature and then carry fr 4 to 18% Ni. The only mines operated at the present time are the Martha a Benno, of which the former has two shaft furnaces capable of treating 50 to of ore daily. The composition of the ore ranges about as follows: SiO_2 60 65·4%, MgO 8·5 to 12%, $Fe_2O_3+Al_2O_3$ 6 to 8%, Ni 2·3 to 3·5%, and ignition l 8 to 15%. Before smelting the ore it is first mixed with gypsum or with calciu sulphite and limestone, crushed to 12 mm. size and pressed into bricks. T shaft furnace is 5 m. high and 1·75 cm. in cross-section, and is charged with t bricks and coke in the proportion of 180 kg. of the former to 50 kg. of the latt A very fluid slag is produced containing 0·3% Ni, which is used in making sl bricks. The matte, composed of about 31·4% Ni, 49·7% Fe and 14·5% S, crushed and subjected to an oxidizing roast in a two-stage reverberatory fu nace, which is 6·13 m. wide and has a capacity of 300 kg. in eight hours. The are four furnaces of this type at the works. The roasted matte containing a proximately Ni 65%, Fe 15% and S 20% is run into a Bessemer converter wi sufficient sand to slag the iron oxide, and is blown for 45 minutes, thus raisi the tenor in nickel to 77·8%. This fine matte is pulverized and treated to dead roast in the reverberatory, which converts it into a grayish-green nick oxide containing 77·6% Ni. The oxide is pulverized, moistened, cut into sm cubes, dried and charged with charcoal into fire brick muffles that are heated a regenerative gas furnace. After three hours' treatment in the furnace, t metal contains 99% Ni and 0·3% Fe. The sulphur dioxide from the roasti is caught in water and the solution neutralized with lime, the resulting calciu sulphite being used as flux in the shaft furnace. During the half year endi *June 30, 1902*, when there were 1,036 laborers employed in the mines and wor the quantity of ore treated was 5,689 tons, which yielded 108 tons of nickel.

[illegible]

of valuable nickel properties on the main or southern range, notably the Murray, Worthington, Mt. Nickel and Sultana, all well developed, which are outside the holdings of the trust. It is seen, therefore, that either the capitalization of the company is too high, or there are very large profits in the nickel industry. The latter conclusion apparently is accepted by the public by reason of the fact that the chief parties in the trust were the main producers and refiners of nickel in America, and that they should, therefore, know what profit is to be derived from the business.

During the summer only two of the ten smelters of the Canada Copper Co were in blast, but in the fall four more furnaces were blown in and work was resumed at three of the mines. The Orford concentrating works at Copper Cliff were operated throughout the year, making into high-grade matte the entire output of the smelters of the Canadian Copper Co.

The Mond Nickel Co. made steady progress during the year. The Victoria mine at Denison, owned and worked by this company, has proved to contain large and valuable body of ore, which is now being exploited below the 500-ft level. At the company's works near the mine, the matte from the smelting furnace is Bessemerized before being exported. The company has also bonded the North Star mine which was operated on a smaller scale during the summer. The smelting plant was closed down in the fall for the purpose of making alteration in the furnaces, but it is intended to start operations again early in 1903.

The Lake Superior Power Co. erected a smelting plant at its chief mine in Creighton, which was in operation during the latter part of the year. Owing to financial troubles, the company closed down the Elsie mine from which the largest part of the ore was produced during 1901, and it is said that the proposed Bessemerizing plant will not be built for some time.

Summarizing the year's progress in the Sudbury district, the output of ore was considerably less than in 1901, but the prospects for the coming year give every assurance of the busiest and most progressive season in the history of the mines. It is probable that there will be six companies operating in the district before the close of 1903.

Chile.—The San Juan group of mines, lying north of the Port of Peña Blanca are located on well formed lodes varying from 1 to 6 ft. in width. The ore consists of oxide, arsenate and sulpharsenide of cobalt with an average tenor of about 4% Co. The workings have reached a depth of from 40 to 70 m.

Germany.—The firm of Basse & Selve produces nickel from Norwegian and New Caledonian ores and occasionally from copper matte. In addition to this firm there are one or two nickel refineries of lesser importance.

A new discovery of nickel ore, apparently of considerable importance, has been made at Sohland, in Lausitz, Saxony. The deposit consisting of chalcopyrite pyrrhotite and copper oxides is associated with a black decomposed diabase. The ore is said to average from 4 to 5% Ni and 2% Cu.

New Caledonia.—(By F. Danvers Power.)—Though nickel has fallen somewhat in price, still so far the miners in New Caledonia have not felt the effect as a reduction in home freights permits the buyers to pay the old prices, in fact

cannot be accounted for either by the falling off of the production, or by an increased demand for cobalt, but was due to an insane competition between the various buyers in New Caledonia, which showed a lack of the sense of responsibility on behalf of some of those who had the handling of other people's money, for all the operators must have had heavy losses in connection with their transactions, the prices paid in Europe not being sufficient to recoup them. Underlying all this was apparently an attempt to drive some of the buyers out of the market, but as the principal competitors were too well matched, they have agreed to cease this cut-throat practice, so the price at the mines has accordingly fallen. The inflated prices naturally caused unusual activity in cobalt mining.

Progress in the Metallurgy of Nickel during 1902.

By Titus Ulke.

Developments at Sault Ste. Marie, Ontario.—During 1902 was demonstrated the commercial impracticability of cheaply roasting Sudbury pyrrhotite nickel ores, which do not average over 25% S, in Herreshoff furnaces in order to utilize the sulphurous acid gas thus obtained to make sulphite pulp or liquid acid. The use of the dead roasted residue in the making of ferronickel was also found to be commercially unsuccessful. It is recognized that unless this roasting in the Herreshoff furnace can be done mainly without the aid of extraneous heat, the cost, compared with heap-roasting, is prohibitive, and that in any case the average percentage of sulphurous acid in the gas produced is too low to be economical for use in the manufacture of calcium bisulphite for making sulphite pulp.*

The roasted nickel ore produced at Sault Ste. Marie was briquetted during 1902, but was not used in the way originally planned by Messrs. Clergue and Sjöstedt; that is, for making ferronickel in electrical furnaces, probably because its copper and residual sulphur contents were too high to yield a satisfactory product. It is evident that ferronickel made in this way would be too costly and too cupriferous for use in making nickel steel commercially.

Later the Lake Superior Co. proposed the treatment of pure nickel ore, that is, ore containing nickel without copper, although it appears that no such ores, in paying quantities, have yet been discovered in the Sudbury district. Furthermore, any hand-picking process of freeing the nickel ore from copper and phosphorus-bearing material which is chiefly contained in the gangue, in order to get these elements low enough to make good pig iron and steel, is impracticable.

Plans and estimates have been prepared, and, it is reported, requests for tenders have recently been made for a large custom nickel and copper smelting and refining works to be erected at Sault Ste. Marie. The site for the plant, whether on the American or on the Canadian side, has not yet been decided upon, although its location in Ontario seems probable, owing to a provision of the Canadian tariff relating to the refining of nickel. The plant, as designed, is

* The statement by Mr. Ulke that the process of roasting pyrrhotite nickel ores, as developed at Sault Ste Marie, proved unsuccessful has been controverted by Mr. E. A. Sjöstedt in the *Engineering and Mining Journal*, April 25, 1903. According to the latter, the process has been worked out in a most satisfactory manner, the pyrrhotite being roasted without extraneous heat and yielding sulphurous acid in quantities that more than repay the cost of converting the raw ore into briquettes. The results of operations for two weeks in 1901 showed an average recovery of 86·45% S, and a total working cost of $1·88 per ton of ore.—[Editor.]

ing of at least 1,400 tons of Sudbury ore daily. At present only four or five of these furnaces are kept running by the company. Its electrolytic refinery, at Cleveland, shut down late in 1902.

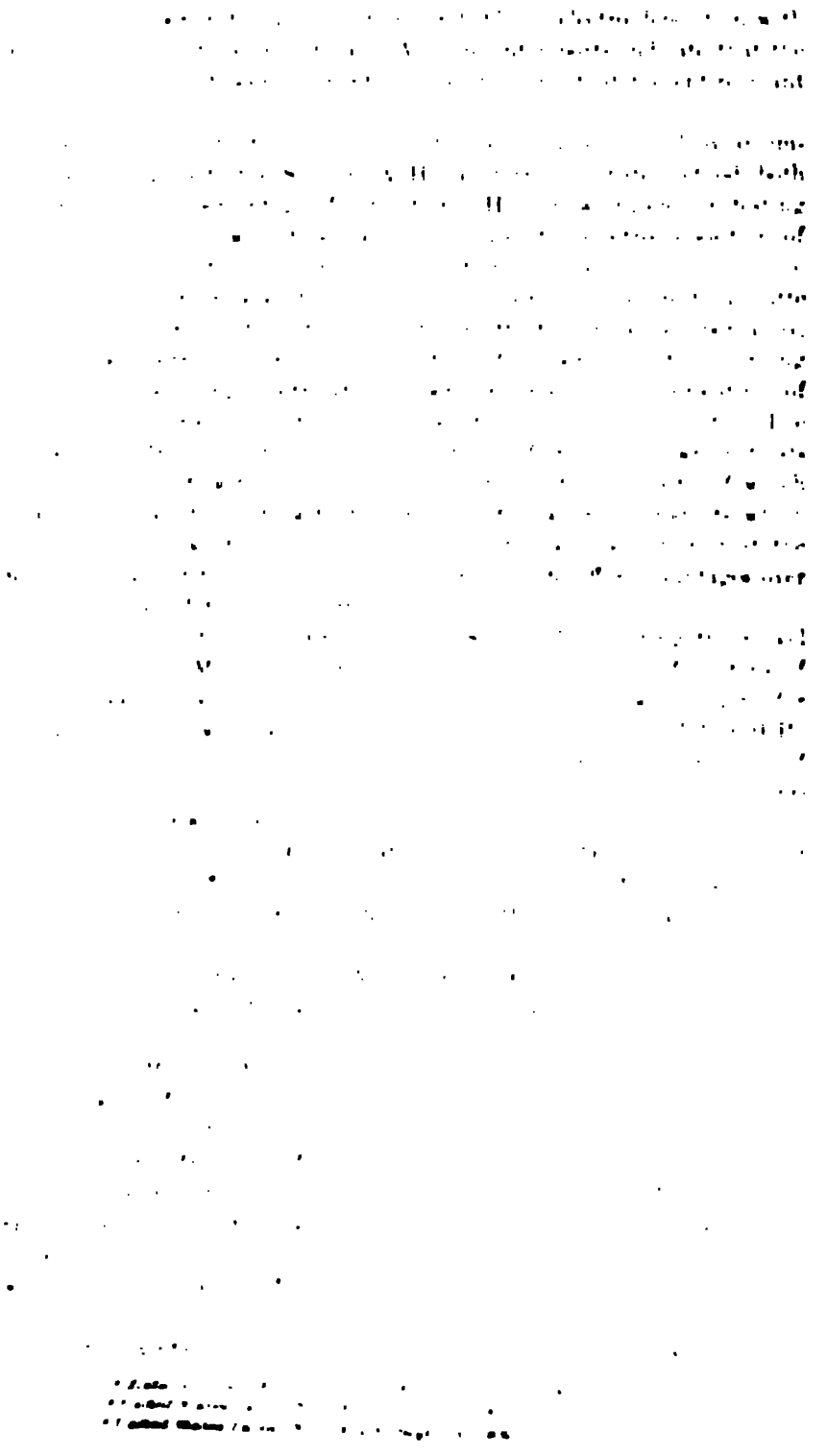
The Orford Copper Co. is now enlarging its two Brown straight-line roasting furnaces near Copper Cliff, and is also putting in a new one.

The Lake Superior Power Co.'s two smelting furnaces at the Gertrude mine, 12 miles from Sudbury, were started during the summer and fall of 1902, and have already produced matte of the estimated value of over $200,000.

Mond's Refinery at Clydach, Wales.—Mond's process of nickel refining, as applied at the Clydach works, Swansea Valley, Wales, is carried out[1] as follows: The Bessemerized Sudbury matte is dead roasted and treated with dilute sulphuric acid, whereby about 66% of the copper and not over 2% of the nickel are extracted. The residue, after drying, assays from 45 to 60% Ni. It is treated in charges of 500 kg. with water gas in a reduction tower at a temperature of not to exceed 300°C. The tower is 7·5 m. high, and contains 14 hollow shelves, which are heated with water gas to 250°C. The ore is moved from shelf to shelf by means of rakes operated by a vertical axle. The lowest shelves are cooled. The reduced charge is transferred to a similar tower called the volatilizer, in which the metal is treated with carbon monoxide at a temperature not exceeding 100°C. The residue from the volatilizing tower is returned to the reducing tower, and the charge goes back and forth between the two towers for from 8 to 15 days. When 60% of the nickel has been volatilized as nickel carbonyl, the residue is returned to the roasting furnace. The nickel carbonyl is treated in the decomposing apparatus, wherein the nickel is recovered as granules assaying from 99·4 to 99·8% Ni. Reports indicate that Mond's volatilization process, although ingeniously worked out in its practical application, developed several weak features, notably; incomplete extraction at several stages of the operation, which make it necessary to hold back considerable nickeliferous material in process for retreatment; danger of explosion; losses in nickel, and poisoning from leakage of CO gas. All of these features seem to militate against the commercial success of Mond's process.

Developments in Germany.—The electrolytic works of the Allgemeine Elektro-Metallurgische Gesellschaft, at Papenburg-a.-d.-Ems., are reported as producing a small output of copper and nickel, according to a modified Hoepfner process, using a chloride solution. The capacity of the works is one ton of refined copper and nickel daily, although the actual output is only a small fraction of a ton. The following process is said to be in use: The ores and matte received at the works are leached with a cupric chloride solution to dissolve the copper, nickel and silver contents, and simultaneously reduce the cupric salt to the cuprous state. After purification and freeing from silver, the solution is passed into electrolytic cells provided with carbon anodes and copper cathodes. Chlorine is liberated at the anodes and utilized; about half of the copper in the electrolyte is recovered by electro-deposition, and the cupric solution remaining after electrolysis is withdrawn and re-used in leaching a fresh charge of ore or matte, until it is found desirable to recover the nickel in the solution. This is done electrolytically, after

[1] *Stahl und Eisen*, Vol. XXII., p. 1062.



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to exceed 300°C. The tower is
which are heated with water gas
by means of rakes operated by
The reduced charge is trans
which the metal is treated v
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viated, or at least considerably
in which metallic or semi-metal
by reducing nickel oxide) is use
or by connecting slabs of crude
circuit, as suggested by Mr. William Th
cathode side would make a staunch back
anode side, besides obviating the nec
It is claimed that electrolytic nickel ca
in this way at a cost of less than 1c.
nickel, the metallurgists of the Bal
were the pioneers in the commercial electr
copper in America, have for many years
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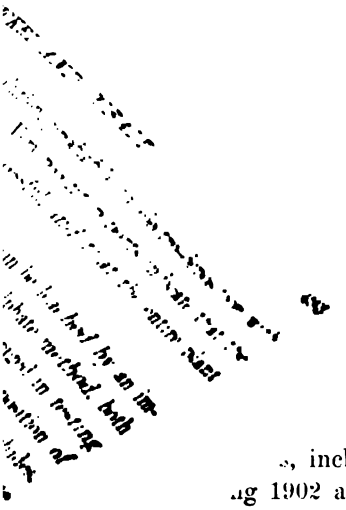
[8] United States Patent No. 714,861, Dec. 2, 1902.
[9] *Electrochemical Industry*, 1903, Vol. I., p. 20



... PIGMENTS.

...THERS.

..., including ocher, umber, sienna and iron ...g 1902 amounted to 55,320 short tons, valued ...th 43,036 short tons, valued at $516,308 in 1901. ...es of these products imported in 1902 and 1901 were ...,408 and 11,149,274 lb. The production of Venetian and ... 1902 was 11,758 short tons, valued at $196,905, as compared with ... tons, valued at $153,467 in 1901. The leading States in the pro- ...cher are Pennsylvania, Georgia, California and Vermont, while iron ... largely from New York, Pennsylvania and Tennessee. Umber and ...roduced chiefly in Illinois and Pennsylvania. Under Venetian and ...s included only the pigment made by calcination of copperas. The ...ers are the American Steel & Wire Co., at Waukegan, Ill., and Worces- ...C. K. Williams & Co., Easton, Pa.; S. P. Wetherill & Co., Phila- ...; George S. Mepham & Co., St. Louis, Mo.; Henry Erwin & Sons, ...Pa., and Hanna & Andrus Co., Chicago, Ill.

...S OF OCHER, UMBER AND SIENNA INTO THE UNITED STATES.

Ocher of All Kinds.					Umber. (a)		Sienna.			
	Ground in Oil.		Total.				Dry.		Ground in Oil.	
...alue.	Pounds	Value.	Pounds.	Value.	Pounds.	Value.	Pounds	Value.	Pounds	Value.
...6,571	31,460	$1,546	5,930,180	$48,117	1,123,079	$9,051	544,713	$11,451	4,008	$280
...72,825	14,881	756	9,780,497	73,581	1,739,036	13,336	758,691	14,242	6,484	492
...57,342	19,167	1,019	8,468,419	58,361	1,703,256	11,862	796,534	14,912	6,335	495
...33,196	16,738	918	8,563,429	84,114	1,465,431	12,510	1,106,553	18,294	13,861	1,004
...67,285	19,668	1,013	10,008,186	108,298	1,894,425	16,133	1,535,377	27,310	5,921	494

...08 lb. ($323) ground in oil and 1,118,471 lb. ($8,728) crude, powdered, washed or pulverized; in ...10) ground in oil and 1,734,187 lb. ($13,036) dry, crude, powdered, washed or pulverized; in ...38) ground in oil, and 1,691,603 lb. ($11,139) dry, crude, powdered, washed or pulverized; in ...1) ground in oil and 1,562,248 lb. ($12,337) dry, crude, powdered, washed or pulverized; in ...10) ground in oil and 1,882,426 lb ($15,444) dry, crude, powdered, washed or pulverized.

... and Venetian red are made from both natural and artificial ma- ...y the latter in connection with the manufacture of copperas, which ...s a by-product from the spent sulphuric acid used in the cleansing ...e rods and tin plate. The copperas which is crystallized in the

Browne's Process for Separation of Copper and Nickel.[5]—This process consists in first treating copper-nickel matte to form copper-nickel alloy substantially free from sulphur, and then treating said alloy with chloride and a solvent for cuprous chloride.

Present Development of Electrolytic Nickel Refining.—The Vivian, Balbach, Cleveland, Hamilton and the Papenburg electrolytic nickel refineries were described by Ulke,[6] who gave many new facts concerning the Vivian and the Balbach plants and the conditions governing profitable refining. The Vivian electrolytic nickel-copper separating works were erected at Swansea, Wales, in 1892, and were designed to treat about 10 tons per week of a nickel-copper alloy produced from Sudbury matte. The Balbach electrolytic nickel refinery was built in 1894, and operated until 1900, during which time about 1,000 tons of electrolytic nickel were produced. With every horse-power of current, averaging between 1·7 and 1·8 volts and 15 amperes per sq. ft. of cathode surface, there were deposited between 2 and 4 tons of nickel per annum out of a hot neutral solution of nickel sulphite. From crude nickel anodes, assaying between 94 and 97% Ni, a remarkably pure and strong metal, containing not more than 0·25% Fe, and practically free from carbon, silicon and sulphur, was obtained. The main drawback of the process adopted was the large amount of scrap produced from the imperfectly smelted and very brittle anodes. It was subsequently found that this difficulty could be obviated, or at least considerably diminished, either by using an anode frame, in which metallic or semi-metallic granules, scrap or powder (easily secured by reducing nickel oxide) is used instead of the more expensive cast anodes, or by connecting slabs of crude nickel, serving as electrodes, in series circuit, as suggested by Mr. William Thum, so that the nickel deposited on the cathode side would make a staunch backing for the crumbling crude nickel of the anode side, besides obviating the need of anode suspension and contact lugs. It is claimed that electrolytic nickel cathodes can be produced from Orford anodes in this way at a cost of less than 1c. per lb.

Besides metallic nickel, the metallurgists of the Balbach Smelting & Refining Co., who were the pioneers in the commercial electrolytic refining of nickel as well as of copper in America, have for many years been producing nickel-plater's salts. The Balbach method of recovering nickel sulphate consists chiefly in repeated fractional crystallizations and a final removal of the remaining copper by electrolysis.

Nickel-Steel Rails.—The results of tests made by the Pennsylvania Railroad with nickel-steel rails at points where the wear is unusually heavy appear to have been favorable, for orders were recently placed for 9,000 tons, the steel to carry 3·5% Ni. Although the price for such rails is very nearly double that of ordinary steel rails, it is believed that their extraordinary toughness and hardness will repay the extra cost. The nickel used in making the rails is metallic nickel, and according to reports, is added in the converter.

[5] United States Patent No. 714,861, Dec. 2, 1902.
[6] *Electrochemical Industry*, 1903, Vol. I., p. 208.

OCHER AND IRON OXIDE PIGMENTS

bottom of the tank is too impure to be of commercial value, and, owing to its limited use, the greater part of it is converted by different processes into iron oxides. There are two principal methods of manufacture, the "dry" and the "wet," details of which are given in THE MINERAL INDUSTRY, Vol. X. In the dry process, which is considered the cheapest for the production of low grades of oxides, the copperas is roasted in a furnace with lime or similar material to neutralize the acid in the sulphate until the desired strength and color of the product are obtained. In some cases copperas alone is roasted until the pure iron oxide remains, which is then mixed with a filler, as whiting or gypsum, to form the different grades of Venetian red, some having as little as 10% of iron oxide or coloring power. The wet process, which is the cheaper for general use, yields a less uniform product. In principle, the waste liquor from the cleansing or pickling process is treated direct for its iron oxide content by the addition of milk of lime, sodium carbonate, or similar reagent, which precipitates the iron as a hydrate or carbonate to the bottom of the tank; subsequently the iron salt is separated from the liquor by filtration through a press, the dried cakes are roasted in furnaces, cooled and packed for the market without grinding. Iron oxides made in this manner are not uniform in quality and have only a limited use. Various colors and strengths of oxides are obtained by the admixture of natural ore and ochers, and iron ores are sometimes ground and sold direct as Venetian reds. The natural products, however, are inferior to the manufactured and do not command as high a price. Great improvements in the processes of manufacture of iron oxides have recently been made, particularly in the dry process. Formerly, the domestic product averaged but 50% Fe_2O_3, but by the construction of crucible furnaces of special design whereby better control of heat and oxidation is obtained, the grade of the product has been raised to chemically pure iron oxide, the supply of which until now had been obtained entirely from foreign manufacturers. The improvements in the wet process are not so marked, although much has been accomplished in the direction of lessened cost of labor by the use of mechanical appliances which in addition has also yielded a more uniform product. It is probable that nearly the entire domestic demand for high- and low-grade iron oxides will be filled in the United States in the near future.

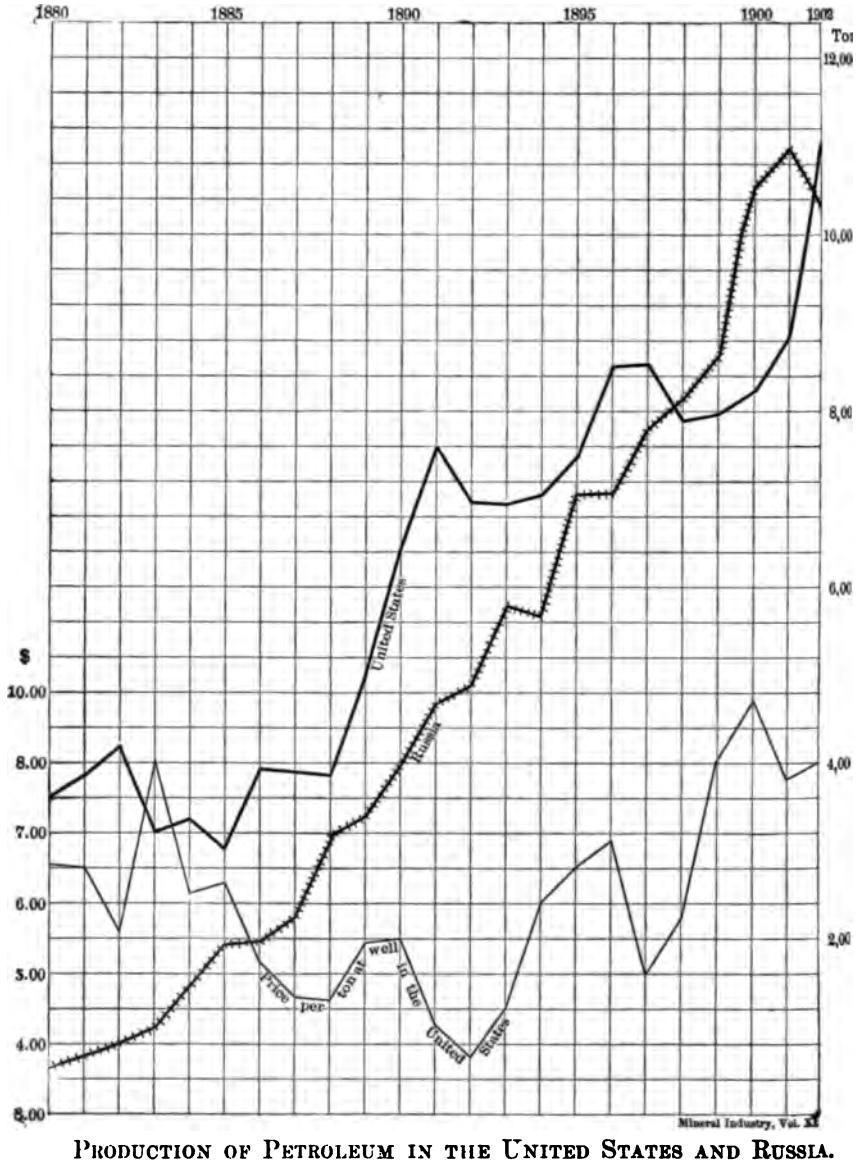
The principal manufacturers of iron oxides and Venetian red are: The American Steel & Wire Co., at Worcester, Mass., and Waukegan, Ill.; C. K. Williams & Co., Easton, Pa.; S. P. Wetherill & Co., Philadelphia, Pa.; Henry Erwin & Sons, Bethlehem, Pa.; George S. Mepham & Co., St. Louis, Mo., and Hanna & Andrus Co., Chicago, Ill. There are also smaller producers in the country who devote their attention to the mined and natural reds only.

Market.—Prices in New York during 1902 averaged about $14 per ton in barrels for mined reds, some of the product mined in Maryland and the South being offered at $10@$11 per bbl. For the manufactured or copperas reds prices averaged about $23 per ton, while for the iron oxide considerably higher prices were obtained, depending entirely upon the strength of iron and color. *During 1902* domestic iron oxide red of high grade in carload lots has been *sold as high* as 6c. per lb.

PETROLEUM.

By D. H. Newland.

pated; a small rise in prices would seriously limit its possibilities for compe with coal, and such an increase may be expected if the refining industry pr to be a commercial success.



PRODUCTION OF PETROLEUM IN THE UNITED STATES AND RUSSIA.

The table on the following page gives an estimate of the quantity of petr produced in the important countries of the world during the period 1897- There are a number of countries that make a small production from which been impossible, so far, to secure any reports, owing to the fact that the ind is conducted in a most primitive manner. China, Persia, Turkey, and seve the South American republics are among the producers not included in this

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (IN GALLONS.)
(1=1,000 IN QUANTITIES AND VALUES.) (*a*)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine.		Residuum.		Totals.	
1898.....	120,496	$5,016	17,257	$1,071	764,823	$38,805	65,526	$7,626	30,436	$815	998,478	$53,423
1899.....	118,690	5,958	18,210	1,597	733,303	49,173	71,105	8,656	21,609	658	962,007	66,042
1900.....	135,161	7,941	18,570	1,681	739,163	54,698	71,311	9,933	19,750	845	985,855	74,498
1901.....	127,006	6,088	21,685	1,743	827,479	53,491	75,306	10,260	27,596	1,255	1,079,059	73,796
1902.....	145,234	6,331	19,683	1,393	778,797	49,079	82,200	10,872	38,316	922	1,064,230	68,597

(*a*) In addition to the above, the following quantities of paraffine and paraffine wax were exported: 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,269 lb. ($8,708).

The following statistics showing the exports of naphtha, illuminating, lubricating and paraffine oils from the United States and Russia during 1902, are of interest. The quantities are expressed in gallons.

Countries.	Naphtha.	Illuminating.	Lubricating and Paraffine.	Total.
United States.....	19,682,627	776,796,758	82,200,133	880,679,518
Russia	.....	319,651,670	44,645,400	364,297,070
Totals.....	19,682,627	1,096,458,428	126,845,533	1,244,976,588

The quantities of crude, residuum and distillate are omitted from both countries. Of the products named in the above table, the United States exported 70·7% and Russia 29·3%, showing a slight decrease for the former country, and a corresponding increase for the latter, as compared with 1901. The average value of the illuminating oil exported from the port of New York was 6·6c. per gal., while the average prices of Russian refined f. o. b. vessels at Baku was 0·77c. per gal.

The chief markets of the manufactured products exported from the United States, Russia and other countries are the United Kingdom and Germany.

The following is an official statement of the importation of petroleum and its products—illuminating and lubricating oils—into the United Kingdom for 1900, 1901 and 1902, in Imperial gallons, which are one-sixth greater than the United States gallon:—

IMPORTS OF PETROLEUM INTO THE UNITED KINGDOM. (IN ENGLISH GALLONS.)

Countries.	1900.	1901.	1902.
United States.....	153,776,766	162,791,899	184,436,176
Russia.....	87,765,897	78,206,964	88,202,548
All other countries.....	13,435,380	12,785,878	12,161,722
Total.....	254,978,043	253,784,746	284,800,446

The exports to Germany for the years 1899, 1900, 1901, have been made up from the countries exporting the manufactured petroleum, and embrace the naphtha, illuminating and lubricating products in gallons exported from the United States and Russia.

While the importations into the United Kingdom from the United States increased from 60% in 1900 to 64% in 1901, those from Russia decreased in the same years from 34% to 31%. In 1902 Russia maintained its relative position with nearly 31% of the imports, and the United States showed a slight gain *furnishing* about 65% of the total. Of the imports into Germany from the two

PETROLEUM EXPORTED TO GERMANY BY THE UNITED STATES AND RUSSIA
(UNITED STATES GALLONS)

the United States furnished 83% in 1900, 87% in 1901, and 79% in

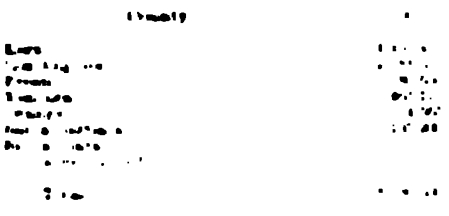
fuel. During 1902 a series of tests was carried out by the Bureau of Engineering United States Navy, with the view of determining the value for the naval purposes. The oil used for the official tests was Beaumont of the following composition: C, 83·26%; H, 12·61%; S, 1·07%; ash 0·06%; flash point 216° F. The calorific value of the oil calculated by Dulong's formula was 19,181 British thermal units. The results are summarized as follows: (a) Oil can be burned in a very smokeless. (b) The evaporative efficiency of nearly every kind of oil per pound of coal is probably the same. (c) Marine steam generators can be worked at as high a degree with oil as with coal. (d) No ill effects were to the boiler. (e) The air required for combustion should be heated before entering the furnace, as such heating assists the gasification of the oil. The oil should be heated until it can be readily atomized. (g) If used for atomizing, high pressures are more advantageous than low. (h) The consumption of liquid fuel probably cannot be forced to the extent with steam as an atomizing agent as when compressed air is

a new type recently put into use in heating and heating furnaces in the shops at Petersburg. After leaving the boiler the steam is superheated in gas regenerators and passes into the furnaces at a temperature of from 600° to 700° Fahrenheit. The fuel oil is burned in a hearth, with double rows of vertical flames from 1½ to 2 inches long, at the regenerator near the bottom. Small quantities of air are admitted at the same time to burn the fuel oil and the unburned gases which would escape the hearth by a chimney flue. The arrangement of the furnaces are similar to those for coal, except that the area of the grate is reduced about 60%. The oil is burned very readily. A burner and boiler of which however has been applied to test the fuel oil, the oil and steam pipes passing through the regenerator, the oil and steam pipes being heated to about 600° Fahrenheit, when steam and oil are admitted to the burner, the oil is atomized by the steam, and a vertical flame is produced. The boiler furnaces were found to be 10% to 15% more economical than coal furnaces, and the temperature of the furnaces and the ease of firing were much greater than with coal-firing.

Alaska.—Discoveries of petroleum have been made recently in the vicinity of Controller Bay, near the mouth of Copper River, where early explorers found some indications of oil from springs. A well sunk 265 ft. yielded high-grade petroleum, containing a large proportion of refinery products and little residue, while another well gave a good lubricating oil. This district is to be actively explored during the summer of 1903.

Appalachian Field.—There was little change in the status of the Pennsylvania and West Virginia fields. The failure of the strong advance in prices during the year to stimulate an increase of output, together with the large number of dry holes put down, created apprehension as to the future, and there is little doubt that the productive areas in these States have been quite closely defined. The unfavorable condition of the producing industry necessitated a heavy drain upon stocks to meet the demand. In West Virginia new oil territory was found in the Salem district of Harrison County, and two pools were opened near Big Knob Run, Ritchie County, which gave a large output. Wetzel and Greene counties also made a favorable showing. An experiment in the pumping of wells by electricity from a central station is to be tried in the Folsom district of Wetzel County. A plant is under course of erection which will be equipped to pump 200 wells, and it is hoped that a considerable economy will be effected over present methods. The Sartwell field in McKean County, Pa., attracted considerable attention during the year with the result that about 1,000 acres of productive territory was proved. The oil is found in the Kane sands at a depth of from 1,000 to 2,000 ft., and is of high quality. In southwestern Ohio a new discovery was reported near Jerusalem, Monroe County.

California.—While the petroleum industry continued in its course of rapid expansion during 1902, the conditions were less satisfactory than in the previous year. In 1901, when an increase of about 100% was registered, the production far exceeded the consuming capacity of the market as then developed, and as a necessary result the prices declined rapidly toward the close of the year. The same relation between production and consumption prevailed throughout 1902, although there was a steadily enlarging demand for the heavy oils for fuel purposes. The crude product of the Kern River field brought as low as 50@60c. per bbl. in San Francisco, which is equivalent to 10@20c. at the wells, while the price of Los Angeles oil fell to 35c. at the wells. Owing to this depression in the market many wells were closed down, and the drilling of new wells was carried on less vigorously than hitherto. The most important developments were made in the search for light oils for which there has been a sustained demand on the part of the existing refineries. Two new fields yielding petroleum of low specific gravity have been opened—the Santa Maria field in Santa Barbara County and the Halfmoon Bay field near San Francisco. In the former the Western Union Oil Co. has brought in 10 deep wells, giving a valuable refining product which can easily be transported to the coast. The Halfmoon Bay field, which is situated close to the sea, yields an oil of from 45° to 52° gravity; several productive wells have been opened, and a small refinery is in operation. The search for light oils continues elsewhere in the State. The important coaling field in Fresno County has maintained an even status, but its development has been hampered by the



by competent chemists show the naphtha and benzine to range from 4 to 6%; illuminating oils, 25 to 28%; paraffine and heavy oils, 55 to 60%; and a residuum (mainly coal tar), 6 to 7%. The refined products are consumed by the Western trade, and the residuum is utilized for fuel purposes. At the close of 1902 there were 57 wells producing and several new holes nearing the oil horizon. There are two local refineries with a combined capacity of about 2,000 bbl. per day. The following is a list of producing companies: Florence Oil Refining Co., Triumph Oil Co., Griffith, Rocky Mt., Fraser Oil & Gas Co., Fremont Oil & Gas Co., Keystone, Columbia Crude Oil Co., and the United Oil Co.

Prospecting in the southwestern and western portions of Colorado is still persistent, numerous surface indications having stimulated activity. In Mesa County, near De Beque, oil was encountered by one company at a depth of 600 ft.; but the flow being deemed insufficient, boring was continued to a depth of 1,300 ft., when a strong flow of salt water was encountered and the hole was abandoned.

Indiana.—During 1902 a new discovery of oil was made near Birdseye, Dubois County, in the southwestern part of the State. The oil-bearing stratum is believed to be the Trenton limestone, the same as in the Lima district, and is encountered at a depth of about 1,000 ft. The first well yielded about 5 bbl. per day. Two additional wells were drilled during the year, and early in 1903 a flowing well was reported to have been brought in by the Standard Oil Co. The Lima district of Indiana was the scene of great activity, the output for 1902 showing a gain of over 30% from the previous year's total.

Kentucky.—Following the discovery of the Sunnybrook field in May, 1901, there has been much activity in the various fields of this State. Many new wells have been put down in the Sunnybrook, Slickford, and Cooper districts, Wayne County; in the Ragland district, Butte County; in the Whitehouse district, Floyd County; and in the Richland district, Knox County. While the output of the individual wells is usually small, the cost of drilling is light owing to the shallowness of the oil horizon. The construction of the pipe line from Somerset to Chambersburg, W. Va., now under way, will give cheap transportation facilities to the fields of eastern Kentucky.

Louisiana.—The discovery of a new oil field in this State in 1902 has given further proof of the wide occurrence of petroleum within the Gulf coastal plain. The productive territory is situated in Acadia Parish about six miles northeast of Jennings and 93 miles east of Beaumont. Development work was started in the summer of 1901 by the Jennings Oil Co. and the Southern Oil Co., both of which found oil but were compelled to abandon the wells owing to clogging by loose sands. In May, 1902, the Southern Oil Co. drilled a third well, utilizing a lining to prevent the creeping in of sand, and oil was encountered at a depth of 1,850 ft. The well proved to be a powerful gusher with a yield of from 20,000 to 25,000 bbl. per day from a 6-in. boring. Other productive wells were opened during the year. The strata penetrated by the drillings consist of clay, sand and "gumbo" with only 8 ft. of firm rock above the cap rock overlying the oil sand, which is said to be more than 15 ft. in thickness. Storage tanks were erected near the wells, and a 4-in. pipe-line laid to the Mermenteau River and to Jennings, whence the oil was shipped by boat and railway. The local markets absorbed most of the year's

worth more for this purpose than upon a fuel basis. The products of refining include illuminating oil, gasoline, spindle and other commercial oils, and asphalt. The Gulf Refinery at Beaumont, when completed, will have an estimated capacity of 24,000 bbl. per day. A part of the plant was operated during 1902. The Burt refinery, southwest of Beaumont, is planned to handle an equally large quantity of crude oil, and two other refineries—one at Port Arthur and the second at Orange—are to be built. These extensive undertakings would seem to indicate that the utilization of Beaumont oil for fuel will not attain the importance that has generally been expected.

The outlay for new equipment in this field during 1902 is itemized below, the estimates being prepared from most reliable sources. Combining the total here given with the total outlay for 1901, it appears that the capital invested up to the end of 1902 was $10,572,085, or 48c. for each barrel of oil produced. These figures, however, do not include the expenditures for drilling outfits and tank cars, or the investments in land which represent a very large outlay, as in many instances small parcels on Spindle Top were sold at the rate of $120,000 an acre.

248 wells at an average of $1,500 each	$372,000	Earthen tankage	$[illegible]
Pipe lines to seaboard	1,100,000	Power plants	[illegible]
Loading racks	28,000		
Refineries in course of erection	2,250,000	Total investment during 1902	$7,175,000
Steel and wooden tankage	2,000,000		

The Sour Lake field, 20 miles northwest of Beaumont, reached the producing stage during 1902. Several flowing wells were put down in the early part of the year, and the region was soon the center of great activity, in which many of the prominent Beaumont companies participated. The results so far obtained indicate that the field has a promising future. Storage tanks of large capacity have been erected and a pipe line laid to Beaumont. The shipments during 1902 were limited by the lack of transportation facilities, the region being isolated from railway lines. It is stated that a tract of 850 acres in this field was sold for $1,000,000. The crude oil resembles that of Beaumont, but is superior to the latter for refining purposes.

New developments were reported in the Saratoga field in Hardin County, 14 miles west of Kountze. In 1895, a well was drilled here which produced oil in small quantities, and recently a flowing well yielding about 500 bbl. per day has been put down. Further exploration is now under way. The oil is very heavy, and nearly free from sulphur.

Utah.—The Green River district attracted considerable attention during 1902, and it is reported that eight wells were drilled which yielded oil by pumping.

Wyoming.—(By Wilbur C. Knight.)—The production of petroleum for 1902 did not show any marked increased over that of 1901, due to the lack of transportation. Wells have been commenced at Hilliard, Spring Valley, Twin Creek, Popo Agie, Powder River, Bonanza, Belle Fourche, Newcastle, Salt Creek, Douglas and near Ft. Steele, and oil has been found at Twin Creek, Ft. Steele and Douglas. Producing wells were completed at Spring Valley, Popo Agie and Salt Creek. The Popo Agie field has eight producing wells, each of which will yield, from the best available data, 200 bbl. per day. These are all spouting wells, and are now packed awaiting transportation. This field could within a very short time supply 1,000,000 bbl. of oil annually. At Salt Creek the Pennsylvania Co.

As to other Continental fields, those in Roumania have shown an increased output, but conditions there have not been favorable to an extension of trade; Galicia has fared even worse, though its output has advanced. Lack of good management and local friction have contributed to the unsatisfactory year's results in both countries.

In the oil industry of the Far East there is nothing special to chronicle beyond the fact that the Standard Oil Co. endeavored unsuccessfully to obtain a foothold in the oil fields of British India.

The Canadian fields have attracted renewed attention during the year, due to the development of a large well which flowed regularly 50 bbl. an hour—the largest yet opened in this country.

In reviewing the occurrences of the year the official visit of Mr. Gulishambaroff, representing the Russian Government, to the Texas oil fields should be noted, and the exhaustive report[1] which he subsequently published in regard to this region.

The working of the English companies in the Russian fields has been attended with unfavorable results during 1902; the consumption of oil for fuel fell off, and prices having been low, the majority of the companies showed either losses or a greatly depleted surplus. The Russian Petroleum & Liquid Fuel Co. has been the only concern to pay a dividend, which was much lower than in previous years.

Austria.—The total quantity of crude oil produced by the Galician wells during 1902 was 576,000 metric tons, exclusive of oil used as fuel. This quantity exceeds that of the previous year by 123,800 tons, or 21·35%, the advance being due chiefly to the great progress made at Boryslaw, where 261,220 tons were produced, which is 46% of the total output. Eastern Galicia contributed 467,300 tons, and Western Galicia 108,760 tons. The number of borings at the close of 1902 was 1,824, showing the average output per well to have been 316 tons. In Boryslaw, however, where the oil was obtained from spouters, the average production per well was 3,000 tons. In this district no less than 125 wells were in course of boring at the close of the year. About 490,230 tons of crude oil were passed through the refineries, but nearly 85,000 tons of this total could not find a market, and consequently there was a considerable fall in prices. During the year 30,930 tons of burning oil were exported to foreign countries, the Galician oil having made good progress in various foreign markets.

Canada.—During 1902 the new oil field discovered at Chatham, Ontario, was the cause of considerable excitement in America and England. The well first brought in at a depth of 357 ft. was a gusher, and produced as much as 50 bbl. an hour. The oil is of good quality and has a gravity of about 34°B., which is about two degrees lighter than the Petrolia oil. The Standard Oil Co. holds land in the vicinity of this well to the extent of 1,900 acres, and among other companies working in the neighborhood is the Canadian Oil Fields, Ltd., an English company already owning a large tract of land with 350 oil wells.

Dutch East Indies.—Considerable attention was devoted to the petroleum industry in this part of the world during the year, but the record of the different

[1] *Petroleum Review*, July 26, 1902.

[illegible] a very variable one. Mr A. V. Ragosine, of Baku, paid an [illegible] visit to these eastern fields, writing a very comprehensive and valuable [illegible] for a Russian journal. These articles were translated and ap[illegible] in the *Petroleum Review*, and are full of interesting data, [illegible] the geological conditions, qualities of the different crude products [illegible] as well as of the refined products, general conditions of marketing, [illegible] a geological point of view, the formation of the Palembang oil [illegible] to the Miocene and that of Langkat to the Eocene period. The [illegible] Java also belong to the Miocene period. The crude oils pro[illegible] a varied character. Some are rich in benzine and others contain [illegible] wax and but little kerosene. Some contain a large [illegible] asphalt while others not only do not contain asphalt, but [illegible] wax. Some oils contain paraffine, others yield residuals suit[illegible] manufacture of fairly viscous lubricating oils, while others are [illegible] from asphalt-forming hydrocarbons. The specific gravity of the [illegible] varies in the following limits: Sumatra, 0·780 to 0·961; Java, [illegible] Borneo 0·810 to 0·[illegible].

[illegible] of pipe lines laid in the Dutch East Indies is considerable. The [illegible] in North Sumatra a pipe line from its fields to the re[illegible] of more than [illegible]. The Moesi Ilir Co is now building [illegible] a pipe line [illegible] from its fields to the refinery [illegible]. Its petroleum production and kerosene in 1907 compared with [illegible] and 1,[illegible] and [illegible], the Sumatra Palembang [illegible] and [illegible] and [illegible] in 1907 [illegible] The petroleum [illegible] of Java made great progress during [illegible]

[illegible]

[illegible]

[

Mexico.—The Mexican Petroleum Co. expended over $500,000 during 1902 in sinking wells and construction work on its property near Ebano, State of Vera Cruz. It is reported that oil was found on the line of the Vera Cruz & Pacific Railroad in Vera Cruz, and encouraging results were obtained in the Masuspama fields of Tabasco.

Persia.—Researches on the Perso-Turkish frontier have proved the existence of an extensive petroleum deposit, and a concession was obtained from the Persian Government for the exploitation of petroleum in that country for a period of 60 years. The oil field is in the Kermanshah province, about 10 miles from the village of Kassershirin, and contains a group of five petroleum hand wells, of which three yield a good quality of oil, and two contain oil mixed with water and slime. For the purpose of delivering the oil on board tank steamers for distribution to the ports of the Persian Gulf, India, and the Red Sea, it is proposed to construct a pipe line to Muhammer, a distance of about 400 miles.

Peru.—The principal companies engaged in the production of petroleum in 1901 were the Establecimiento Industrial de Zorritos operating in the district of Tumbas, and the London Pacific Petroleum Co., in the district of Payta. The total output for the year was 11,272,400 gal. crude petroleum, of which 3,258,000 gal. was refined and yielded 516,920 gal. kerosene, 667,412 gal. benzine, and 1,983,500 gal. residuum, while about 6,400,000 gal. were sold in the crude state.

Roumania.—The oil industry of Roumania during 1902 has been the victim of adverse circumstances resulting chiefly from the unsatisfactory condition of the Russian industry. While the production of oil showed an advance in all other aspects the year was a poor one. Prices for crude oil, which stood at 4 fr. per 100 kg. in October, 1901, were as low as 3 fr. in April, 1902, declining toward the end of the year to 1·90 fr. The natural result of this fall in price was that a number of producers had to reduce their output, while much boring work in progress was brought to a standstill.

The output from the Roumanian wells from 1893 to date is given in the following table:—

Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.
1893.....	56,600	1897.....	110,000	1900.....	250,000
1894.....	64,530	1898.....	180,000	1901.....	270,000
1895.....	76,000	1899.....	250,000	1902.....	310,000
1896.....	80,000				

The districts from which the output in 1902 was obtained, with the contribution from each, were as follows: Prahova, 259,000 tons; Dambovitza, 33,000 tons; Baicoi, 13,000 tons; Buzeu, 5,000 tons.

The chief producing company in the country is still the Steaua Romana Co., although much important work has been done by the International Petroleum Co. and the Telega Oil Co.

During the year the districts of Griusor and Baicoi in Prahova and Gura Ocnita in Dambovitza have been prominent. In the Baicoi district prospecting work led to the discovery of a large deposit of ozokerite.

One of the chief disadvantages from which Roumania has suffered during the

10,879,736 metric tons, equivalent to 76,383,463 and 80,553,152 bbl., respectively. The proportionate contributions from the various fields and the average depths of the wells during the last five years were as follows:—

Field.	Percentage of Total Production.					Depth of Wells.				
	1898.	1899.	1900.	1901.	1902.	1898.	1899.	1900.	1901.	1902.
						Feet.	Feet.	Feet.	Feet.	Feet.
Balakhany	22·4	21·8	20·6	17·8	16·3	720	795	749	749	714
Bebe-Aibat	19·9	15·2	18·2	19·7	20·2	1,601	1,209	1,211	1,229	1,581
Romany	20·7	17·6	18·9	18·0	21·2	1,429	1,229	1,428	1,436	1,461
Saboontchi	37·0	43·8	41·4	41·9	42·4	905	994	847	980	994

Saboontchi has thus practically held its place as a producer among the Baku districts, while each of the other fields has registered a marked decline. It is to be noted also that the average depth of the wells has increased.

In order to show in more detail the condition of the Russian fields relative to the descriptions of wells the following table is presented, giving the production by "spouters" and pumping wells.

	1902.		1901.	
	Spouters.	Pumping.	Spouters.	Pumping.
	Tons.	Tons.	Tons.	Tons.
Balakhany	.....	1,637,165	.....	1,899,739
Saboontchi	163,650	4,145,866	612,163	4,150,008
Romany	621,720	1,535,410	407,506	1,647,728
Bebe-Aibat	743,310	1,312,059	613,977	1,541,073

It will thus be seen that Bebe-Aibat has again broken the record in the way of increased output by spouters. Romany has also made a great advance in this respect, while Saboontchi has experienced a very great decline.

The stocks of crude oil at Baku at the close of the year compared with the previous year were:—

	Jan. 1, 1902.	Jan. 1, 1903.
At the wells	2,058,963 barrels.	1,015,056 barrels.
At the refineries	6,850,733 barrels.	3,378,335 barrels.

The course of Russian prices during 1902 has been a gradual progression, opening the year with crude at 5@5·25 kopecks per pood, refined at 6·5@6·75 kopecks, and residuals at 6@6·25 kopecks. As a contrast to this, the year 1901 opened with prices of crude at 11·725@11·75 kopecks, refined at 15 kopecks, and residuals at 13·5 kopecks. At the close of the latter year, the figures had fallen to 6@6.25, 6·75@7, and 6·75@7 kopecks respectively, a remarkable agreement in price for the different products. This anomalous condition of things continued into 1902, the price for crude still rising, refined falling, and residuals rising. At the middle of the year the market took a turn for the better, although crude still continued to rise. This was the first point of improvement, and at the end of July, refiners saw the first favorable balance between the price of the crude and their products. With one or two fluctuations, this amelioration was carried through the remainder of the year when prices were: Crude, 8 kopecks; refined, 15 kopecks; and residuals, 7·125 kopecks.

The export of refined Russian oil showed a falling off, a result that was unexpected in view of the low prices prevailing at Baku. The principal part of

gravity is not more than 0·8641 or 31°B. The products obtainable by distillation are: kerosene, 36%, and heavy oils, 30%.

During the last two years work in the oil fields of Tcheleken has been proceeding actively. Apart from several spouting wells there are more than 50 wells on the island now producing, the oil being pumped. Nobel Bros. has started a 26-in. borehole on its Alia-Tepe plot. Altogether the number of borings on Tcheleken amounts to about 100.

The district of Berikei has also been exploited during the year. The property is situated about five miles from Berikei, 25 miles from Derbent and about 230 miles from Baku. On Dec. 12, 1902, a trial boring having a depth of 1,365 ft. and a diameter of 12 in. began to spout, but was soon stopped by a cork being formed. The well was subsequently opened again, but the yield did not exceed 6,000 poods per 24 hours. Prospecting work on the adjoining plots is attended with little success, although indications of oil are found there.

South Africa.—A deposit of petroleum exists in the Wakkerstroom district, but it is not certain that oil is present in paying quantities. According to the latest report by Mr. E. Cave, the indications of petroleum are most pronounced. One locality known as the "oily" spring, is situated upon an anticlinal in the Pongola mountain chain.

Spain.—Up to the present time little has been done in connection with the production of petroleum in Spain, although deposits are known to exist. The Sociédad Española á de Sodeos has sunk borings at Salvatierra to a depth of 325 ft., under the direction of Federico Luzuriaga. Salvatierra is situated in the narrowest part of the Alva plain in a valley enclosed on one side by the mountains of Elgea and San Andrian and on the other side by those of Eucia and Urbasa. The surface of the ground is very broken, and the sedimentary strata running from east to west, have a varying dip toward the south. Veins of calcite with a strong odor of petroleum cross each other in all directions, forming a network. The more important of these strike northeast and southwest. About 16 km. southwest of Salvatierra are situated the celebrated asphalt mines of Maetsu, which according to Mr. Adan de Yarza, are situated 2,670 ft. above sea level, while Salvatierra is at an altitude of only 1,940 ft. The north of Spain falls within the petroliferous region of Europe, and petroleum is known to exist in large subterranean pools, especially in regions close to mountain ranges and sea coasts; while the asphalts are at a higher level than the naphtha bitumens and liquid hydrocarbons.

Turkey.—Mr. J. E. Spurr describes the oil resources of the Turkish Empire in the *Engineering and Mining Journal*, Oct. 4, 1902. Fields of considerable extent and of possible future importance are known to occur in the southeastern part of the Empire in the vicinity of Bagdad. The oil-bearing strata are apparently of Tertiary age, from which the petroleum exudes and collects in little lakes at the surface, these occurrences having been known to the inhabitants for a long time. The conditions are apparently similar to those obtaining in the oil districts of Persia near the Turkish frontier, and in the Russian oil fields of Baku. Oil is said to exist also on the south shore of the Black Sea, being here a continuation of the Baku field. On the southwestern coast of Asia Minor north of Cape

[illegible] as the famous Chimæra of the ancient Greeks. Here gases are continually escaping from fissures, and are known to have been burning for at least [illegible] years, as the phenomenon was described by Hesiod before the time of [illegible]. According to the Russian geologist Tchihatcheff the gas is emitted from [illegible] altered igneous rock (serpentine) which is intrusive in limestone. In connection it is interesting to note that burning wells were known in the [illegible] before oil was discovered. It is an open question whether the escaping [illegible] (modern Turkish, *Janardagh* "eternal fire") is of organic origin and indicative of oil below, or is due to volcanic action. The facts, however, seem to favor the former alternative, as the igneous rocks [illegible] do not indicate recent volcanic activity. As is often the case, there seems to be a general connection between petroleum and natural asphalt in the Turkish Empire. Asphalt deposits are known in a number of localities of [illegible] as Albania near the Adriatic and in Palestine deserve particular [illegible]. From a general consideration of the facts noted it seems quite possible that important oil fields may be developed in this country.

PHOSPHATE ROCK.

By Joseph Struthers.

The production of all varieties of phosphate rock in the United States during 1902 amounted to 1,464,668 long tons, valued at $4,636,516, as compared with 1,483,723 long tons, valued at $5,316,403, which shows a decrease of 38,955 long tons in quantity and $679,887 in value from the statistics of the earlier year.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (*a*) (IN TONS OF 2,240 LB.)

Year.	South Carolina.	Florida.	North Carolina.	Tennessee.	Other States.	Total		
						Quantity.	Value.	Per Ton.
1897	333,626	543,490	7,000	121,251	2,000	1,007,367	$3,032,101	$3·00
1898	434,273	546,881	2,200	272,191	2,100	1,257,645	4,355,035	3·46
1899	476,238	706,677	15,000	462,561	3,000	1,663,476	6,350,144	3·82
1900	414,084	642,321	17,500	450,856	3,000	1,527,711	5,375,956	3·52
1901 (*c*)	321,181	751,996	*b* 20,000	409,653	593	1,483,723	5,316,403	3·58
1902 (*c*)	313,365	759,784	*b* 25,000	390,799	720	1,464,668	4,636,516	3·17

(*a*) The figures for 1899 are based on railway and export shipments, except those for Tennessee, which were furnished by the Commissioner of Labor and Inspector of Mines. In 1898 and 1897 the statistics were compiled partly from shipments and partly from direct reports of the producers. (*b*) Low-grade rock not used for fertilizing purposes and not included in the total production. (*c*) Through the United States Geological Survey, statistics based on marketed output.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES DURING 1901 AND 1902, CLASSIFIED AS TO VARIETY. (IN TONS OF 2,240 LB.)

Year.	Marketed Output.									
	Florida.						South Carolina.			
	Hard Rock.		Land Pebble.		River Pebble.		Land Rock.		River Rock.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1901	457,568	$2,393,000	247,454	$460,702	46,974	$105,691	225,189	$716,101	95,993	$345,720
1902	429,384	1,743,694	325,845	754,588	5,055	8,987	245,243	752,220	68,123	163,935
	Quantity Mined.									
1902	447,445	1,862,704	305,751	721,975	5,456	9,711	254,556	773,005	75,803	184,207

Year.	Marketed Output.					
	Tennessee.		Other States.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1901	409,653	$1,192,090	893	$3,000	1,483,723	$5,316,403
1902	390,799	1,206,647	720	2,975	1,464,668	4,636,516
	Quantity Mined.					
1902	396,015	1,210,673	2,445	8,500	1,487,471	$4,770,775

In considering the two tables given above, it should be remembered that the statistics pertaining to the years 1901 and 1902 have been based on the marketed output and not on the actual quantities mined, an arrangement which, in the absence of exact figures of stocks on hand at the beginning of each year, presents more clearly the relation between the consumption and supply.

In general, the phosphate rock industry in Florida, South Carolina and Ten-

1901, and the weakness was apparent also in the European markets. The c. i. f. prices abroad fluctuated from $5·67 to $6·30, averaging $5·98 for the year, against $6·88 in 1901. Ocean freight rates ruled at $2·64@$2·94 to France, and $2@$3·12 to Great Britain, these countries absorbing most of the exports.

SHIPMENTS OF PHOSPHATE ROCK. (IN TONS OF 2,240 LB.)

States.	1900.			1901.			1902.		
	Foreign.	Domestic.	Total.	Foreign.	Domestic	Total.	Foreign.	Domestic.	Total.
South Carolina	63,500	399,500	463,000	45,709	275,472	321,181	55,000	247,125	302,125
Florida	410,000	120,000	530,000	548,315	191,361	739,676	627,015	257,330	884,345
Tennessee	135,000	280,000	415,000	164,399	245,264	409,663	139,500	298,000	437,500
North Carolina	.....	17,500	17,500	.....	20,000	20,000	*Nil.*	*Nil.*	*Nil.*
Pennsylvania	*Nil.*	1,000	1,000	.....	953	953	*Nil.*	*Nil.*	*Nil.*

YEARLY SHIPMENTS OF HIGH-GRADE FLORIDA PHOSPHATE ROCK. (*c*) (IN TONS OF 2,240 LB.)

Countries.	1899.	1900.	1901.	1902.	Countries.	1899.	1900.	1901.	1902.
	Tons.	Tons.	Tons.	Tons		Tons.	Tons.	Tons.	Tons.
Austria	.....	5,923	8,114	14,310	Italy	4,546	.....	5,842	16,368
Belgium	37,108	31,639	58,181	41,245	Norw'y & Sweden	11,988	8,000	6,750	10,920
Denmark	5,475	2,930	6,064	2,750	Russia	1,700	2,702	.....	2,600
England	31,789	20,542	28,790	30,068	Scotland	9,545	1,790	6,185	12,480
France	3,165	.....	6,498	3,950	All other (*b*)	8,360	6,406	6,098	8,068
Germany	243,887	208,422	214,280	264,550					
Holland (*a*)	87,167	54,349	72,158	77,176	Total	444,675	348,556	424,130	492,610
Ireland	.....	5,852	5,175	8,850					

(*a*) A large proportion of the shipments to Rotterdam is forwarded to the interior of Germany. (*b*) Included in these shipments are those made to the United States, Australasia, Japan, Spain, and the West Indies. (*c*) From the annual report of Anchincloss Bros.

Imports and Exports.—The total imports of phosphate rock in 1902 (not restricted to the quantity entered for immediate consumption) amounted to 137,386 long tons, valued at $646,264, as compared with 175,765 long tons, valued at $872,503 in 1901. The total exports of phosphate rock in 1902 amounted to 802,086 long tons, valued at $6,193,372, as compared with 729,539 long tons, valued at $5,839,245 in 1901. The exports of Florida high-grade hard rock were 492,610 long tons in 1902, as compared with 424,130 long tons in the preceding year.

THE WORLD'S PRODUCTION OF PHOSPHATE ROCK. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Algeria.		Belgium. Cubic Meters.		Canada.		France.		Norway.	
1897	222,141	$912,564	350,056	$496,702	824	$3,984	535,390	$2,852,887	*c* 872	$12,9
1898	269,500	1,078,000	156,920	303,290	665	3,665	568,558	3,115,958	3,598	53,3
1899	334,968	1,290,932	190,000	342,180	2,722	18,000	645,868	3,384,145	1,500	22,2
1900	319,423	1,277,688	215,670	367,164	1,284	7,105	587,919	2,827,291	300	4,4
1901	265,000	1,060,000	(*f*) 222,590	361,398	987	6,280	535,676	2,614,543	(*e*)	(*e*)

Year.	Redonda, Br. W. Indies. (*d*)		Russia. (*b*)		Spain. (*b*)		United Kingdom.		United States.	
1897	812	$5,525	5,917	$22,132	2,084	$16,672	2,082	$17,500	1,083,495	$3,022,1
1898	750	4,725	1,870	4,784	4,500	46,008	1,575	13,565	1,257,645	4,355,0
1899	1,507	9,250	16,863	58,640	3,510	35,100	1,469	12,645	1,663,476	6,350,1
1900	2,280	13,720	(*e*)	(*e*)	4,170	18,590	630	5,425	1,582,154	5,375,9
1901	*Nil*	.....	(*e*)	(*e*)	4,220	16,880	71	680	1,527,681	5,395,4

(*a*) From the official reports of the respective countries and *Annual General Reports on the Mineral Industry of the United Kingdom*, by C. Le Neve Foster. (*b*) Phosphorites exported. (*c*) Apatite exported. (*d*) Aluminum phosphate exported. (*e*) Statistics not yet published. (*f*) Metric tons.

[illegible] Mineral Industry of the United States during 1907

By [illegible]

[illegible]

hard rock, except that a number of operators are installing dredges of the dippe type to mine deposits that have been worked down to the so-called "water-level," particularly in those cases where it has been found impracticable to handle th water with pumps. Mining with dipper dredges presents many economical fea tures. With deposits which can be handled by this method, it has given ver excellent results and has made it possible to treat profitably many deposits othe wise of no commercial value. A dredge should not be installed, however, unt it has been ascertained that the deposits are of a character suitable for dredging the conditions must be filled exactly in order that the work shall be successfu The expense of the installation of a dredge is considerable, and in event of failu the loss would be heavy. It is interesting to note the innovation that has a peared in the works of the Prairie Pebble Phosphate Co., where a central plant h been installed for the generation of electric and hydraulic power for the minin operations. The results have proven very successful and economical, and und proper conditions this method promises eventually to supersede the older metho The fuel question is the most serious one to be considered, and the producers a securing large tracts of wood lands for fuel supply. It is merely a question a comparatively short time when coal will be substituted for wood, a change whi will be speedily adopted when the mines control the transportation to the port shipment.

The tendency in the pebble rock district, as in the hard rock district, is towa centralization and combination, and negotiations are already under way th will bring the various mines under the control of two or three companies. N new mining plants have been constructed during 1902, nor has there been a extension made of the known phosphate territory. Such deposits as have be opened up have been promptly purchased by the present operators.

The usual amount of prospecting has been carried on during the year, but extension of known territory has been made, nor have any extensive finds be reported. Some of the so-called exhausted deposits have been extended, a matt which has caused no surprise, as prospecting is now carried on with exception care, and through a greater depth of overburden than was formerly the ca As a result of this more thorough exploration, deposits are now being develop in land which was formerly passed over. The mining of deposits having a hea overburden is a sure indication that the operators realize that the deposits hard rock phosphate are by no means inexhaustible.

The excessively high transportation and terminal charges prevailing in rece years have forced the miners to seek relief. The Dunnellon Phosphate Co., whi was the first to take this matter in hand, has constructed a railroad 18 miles length from its central plant at Rockwell to the mouth of the Withlacooch River, where a port has been opened, known as Port Inglis. A large sum money was expended in this work, which was completed during the year, a has so far proven eminently successful. The entire output of the compan mines is now handled through this port.

In general, there appears to be a tendency toward a combination of the larg producers and the gradual absorption of the smaller mines by the larger ope tors. The indications are that in the near future the entire business will

In general, while new finds have been noted from time to time, in various parts of the State, no developments of commercial importance have been made.

An interesting and valuable report on the white phosphate rocks of Tennessee has been prepared for the United States Geological Survey by Dr. C. W. Hayes and Mr. E. C. Eckel. The report, which is now in press, embraces the deposits in Perry and Decatur counties.

General.—Taken as a whole, the phosphate industry of the United States is in a healthy condition. The producers in the various sections are combining for mutual advantages, and there has been a marked increase in the domestic demand; the business, as a whole, has passed through the various stages of development, and may now be considered as established on a firm basis.

According to the bulletin issued by the U. S. Census Bureau, there are 422 fertilizer works in the United States, exclusive of 18 small establishments, each of which reported a value for all products of less than $500 during 1900. The 422 establishments produced 923,198 tons of superphosphate, valued at $8,471,943, 142,898 tons of ammoniated superphosphate, also 1,436,682 tons of "complete fertilizers," by which is meant a mixture of superphosphate with both potash and ammoniates, valued at $25,446,046, and 291,917 tons of other fertilizers, including bone meal and similar substances, valued at $4,178,284.

Porto Rico.—Deposits of calcareous phosphate are reported to occur at San Germán, Cabo Rojo, Lajas, Isabela, Manati, Ponce and Pueblo Viejo, and many concessions have been granted for exploitation. The largest deposits, however, are on the islands of Caja de Muertos and Mona. The former is situated south of Porto Rico, 8 miles from Ponce, and contains an immense deposit of phosphate and guano of satisfactory composition. The right of exploitation on this island was awarded to Miguel de Porrata Doria in 1899. The Island of Mona is situated west of Porto Rico, 34 miles from the city of Mayaguez, and contains a phosphate deposit of very high grade character, the right to exploit which was granted by the Spanish Government, in March, 1877, to Porrata Doria and Contreras & Co., the concession to hold good until 1907.

Phosphate Mining in Foreign Countries.

Algeria.—The production of phosphate rock in 1902 amounted to 270,252 metric tons, a decrease of 4,249 tons as compared with that of the previous year. Of the total output in 1902, 84,685 tons were exported to Great Britain, 79,817 tons to France, 40,455 tons to Germany, 32,276 tons to Italy, 12,600 tons to the Netherlands, 6,349 tons to Spain, 4,500 tons to Russia, 3,015 tons to Belgium, 2,805 tons to Portugal, 2,570 tons to Austro-Hungary and 1,000 tons to Roumania. The phosphate rock industry has been developed rapidly until it has become the most important mineral product of Algeria. The first shipments of commercial importance were made in 1893 amounting to about 5,000 metric tons and while the output during 1902 was less than that of 1901, the decrease comparatively small. The rock is quarried in the vicinity of Tébessa and Toqueville in the Province of Constantine.

The deposits of the Tébessa group are in a chain of mountains extending in

[illegible] W —N E from Djebel-Djerrar on the south to Dyrel-Kef on the north, [illegible] the presence of considerable quantities of ore over a distance of nearly

The three principal centers of exploitation are: (1) Djebel-Kouif, ex[illegible] the Constantine Phosphate Co., (2) Am Kessa, exploited by La Société [illegible] Tebessa, (3) Dyr, exploited by Cookstone Brothers, of Glas[illegible]

[illegible] of Djebel-Kouif are on the frontier separating Algeria from Tunis, [illegible] of Tebessa. The region consists principally of two large plateaus [illegible] Dyr at the altitude of 1,100 m. in Algeria, and that of Ameel-Kebir [illegible] of 1,150 m. in Tunis. A single layer of phosphate has been dis[illegible] ag at times 6 m. in thickness, which seems to extend over the two

The rock is obtained by quarrying. The Constantine Phosphate Co. [illegible] to exchange by a branch track to the Tebessa station of the Bone-[illegible] which permits the direct transportation of the phosphate to the [illegible] transshipment. The branch road is 30 kilo. in length.

[illegible] Kessa, 7 km. north of Tebessa, the quarries of the French Phosphate [illegible] with the station of Youks les Bains by a small narrow gauge [illegible] 9 km. in length.

[illegible] the name of Dyr is designated a large rectangular plateau 30 km. in [illegible]. The rock is mined, the overlying stratum being nummulitic [illegible]. The mined material is conveyed to the railroad partly by aerial cable [illegible] of these beds of phosphate to the French possessions in northern [illegible]

[illegible] Numerous beds of phosphate rock, 30 miles S.W. of Dunedin, New [illegible] have been reported. The deposits are of large area and underlie the country [illegible] The analyses [illegible] the average [illegible] of the lower grade [illegible] which occurs in a layer [illegible] in thickness averages [illegible]. A specimen of phosphate rock [illegible] Murray flats near Ruby station, South Victoria [illegible]

[illegible] no direct production of phosphate rock in Queensland, but [illegible] deposits of it [illegible] in the mining [illegible] [illegible] [illegible]

tons, valued at $2,614,543, as compared with 587,919 metric tons valued at $2,827,291 in 1900. The rock was produced in 23 departments, the greatest production being in the departments of Pas-de-Calais, Somme, Aisne, Meuse, Oise, Ardennes, Lot, Indre, Nord and Manche. The Department of Somme produced 265,000 metric tons in 1901, the principal quarries being at Vaux-Éclusier and other villages of the districts of Péronne, Marcheville and Beauval. The Department of Aisne produced 133,000 metric tons, the quarries being at Étaves-Bocquiaux and Hargicourt. In the Department of Pas-de-Calais, the mines of Orville et Auxi-le-Château produced 64,000 metric tons. The output from the Department of Meuse amounted to 23,000 metric tons, and for the Department of Oise, 20,000 metric tons.

Polynesian Islands.—The phosphate deposits of Ocean Island, in the Gilbert group and Nauru or Pleasant Island in the Marshall group, have been described in detail by F. Danvers Power in THE MINERAL INDUSTRY, Vol. X., pp. 533-535. The deposits on Ocean Island are exploited by the Pacific Islands Co., operating under a 99-year lease from the British Government. Two stations have been established, one at Home Bay and the other at Tapiwa. A track has been laid extending to the end of the long jetties, when the rock is conveyed by large surf boats to steamers made fast to moorings a few hundred yards distant. The company employs 25 white laborers and 300 natives. The total shipment of phosphate which is consumed chiefly in the Australasian markets has amounted to approximately 50,000 tons. The following analysis of a 3,000-ton shipment has been reported: CaO 52·83%, P_2O_5 39·78%, ($=Ca_3(PO_4)_2$ 86·85%), CO_2 1·47% ($=CaCO_3$ 3·35%), Fe_2O_3 and Al_2O_3 0·44%, SiO_2, MgO, SO_3, K_2O and Na_2O 2·46%, H_2O (combined) and organic matter 3·02%.

On Christmas Island, the deposits of phosphate rock were actively mined during 1902, the exports amounting to 57,544 tons as compared with 46,898 tons in 1901. The formation of the phosphate has resulted from the alteration of limestone by the percolation of meteoric waters from the overlying deposits of guano.

Norway.—The annual production of phosphate rock (apatite) in recent years has averaged less than 2,000 metric tons. Several companies operating the mines at Bamle near Kragerö have formed a combination with a capital of $200,000. The entire production is exported, and in 1902 the quantity shipped amounted to 3,600 metric tons.

Russia.—Extensive phosphate deposits occur in the provinces of Podolia, Bessarabia, Kostroma and Smolensk. The output during 1900 was obtained from Podolia and Bessarabia, and amounted to 25,663 metric tons, as compared with 1,868 metric tons in 1899. The area of the deposits in Podolia extends over 1,775 sq. miles, while in Bessarabia, 270 sq. miles are covered. Analyses of the rock show a phosphoric acid content as high as 30%, which is equivalent to 75% of tribasic calcium phosphate. The output of rock is consumed in part by the fertilizing factories, which have increased their output of superphosphates due to the development of the beet sugar industry. The quantity of superphosphate fertilizer produced from domestic rock is not sufficient to supply the demand, and is supplemented by imports of phosphate rock from the United States.

The output of phosphate rock is limited to the mines of the Compagnie [illegible] du Djebel Kouif, which operates the deposits at [illegible]. During 1901 the mine gave employment to nearly 1,000 laborers and masons of Sardinians, Moors, Kabyles, and Tunis Arabs. During the summer the material is dried in the air, while in the winter various types [illegible] are used for this purpose.

phosphate deposits in Kalaa-Djerda, which have been the object of litigation, consist of strata varying from 12 to 25 ft. in thickness [illegible]. The phosphate rock contained in the deposits has been estimated at [illegible] but the yearly output is less than 0.5% tribasic phosphate [illegible]. The exports of phosphate rock during 1901 amounted to 201,193 metric tons, [illegible] 172,175 metric tons in 1900. Of the former quantity the five countries to which the production was shipped were France, 100,307 tons; [illegible] 30,000 tons; Italy, 31,000 tons; Great Britain, 18,000 tons; and Holland, 1,700 tons.

PLATINUM AND IRIDIUM.

By Joseph Struthers.

The production of platinum from domestic ores in the United States during 1902 amounted to 94 oz., valued at $1,814, as compared with 1,408 oz., valued at $27,526 in 1901, which was the largest quantity reported for any one year since the statistics of the production of the metal from domestic ores have been collected. The large decrease in the production of this important metal during 1902 places the industry very nearly on the basis of 1894, in which year the production of platinum from domestic ores was 100 oz. of crude platinum grains. A reference to the quantity of platinum annually imported into the United States, shows the comparative insignificance of the domestic production to the total consumption in the United States. In connection with the production of platinum from domestic ores during 1902 there were obtained also 20 oz. of iridium, as compared with 253 oz. in 1901. Iridium is so closely allied to platinum in its properties, that doubtless it has formed at least 15% of the platinum production reported in early years.

The domestic supply of platinum in recent years has been obtained as a secondary product chiefly from gold placer deposits in Trinity and Shasta counties, Cal. The occurrence of the metal has been reported in many other gold placers of California, as well as in Washington, Oregon, Idaho, Montana, Colorado and Alaska; the deposits, however, have not been sufficiently rich to place the extraction of the metal on a profitable basis. There have been very few new reports of discoveries of platinum during the year. The Rambler district, near Encampment, Albany County, Wyo., continues to attract attention, and one or two other mines in that region claim to have covellite (CuS, copper sulphide) carrying sperrylite ($PtAs_2$, platinum arsenide) in the ore. According to S. F. Emmons[1] the gangue rock of the Rambler mine consists of quartzite with some limestones and conglomerates, penetrated by sheets and dikes of eruptive rocks, mainly diorite. In one zone the diorite is decomposed, and forms a white kaolinized mass of the consistency of soft clay. Covellite is irregularly distributed throughout the mass, but sometimes occurs in massive lenses in thickness varying

[1] United States Geological Survey, Bulletin No. 213.

The conclusions of practical value arrived at by Prof. Kemp are: (1) That platinum is very sparsely distributed in the mother rock so that the chances of finding it in quantity sufficient to mine are small; also, if found, the recovery of the platinum other than by stamping and washing is yet to be solved, as the metal may be in a very finely disseminated state and its extraction will necessarily be difficult. (2) Large and permanent placers may be sought only on very old land areas which have been subjected to protracted degradation and concentration. (3) In the assay of antimonial, arsenical and other copper ores (especially tetrahedrite) it is advisable to search for small percentages of platinum. (4) Deposits of chromite should be tested for the presence of the metal.

Imports.—The imports of platinum into the United States during 1902 are reported as follows: Unmanufactured, 632 lb. ($172,967); ingots, bars, sheets and wire, 6,713 lb. ($1,778,395); vases, retorts and other apparatus, vessels and parts thereof for chemical uses, $34,913, and manufactures not specially provided for, $2,705. Practically the entire supply of platinum in the United States during 1902 was derived from foreign sources.

Market.—Despite the attempts that have been made to replace platinum by other metals or alloys, the demand for it has continued to increase, and as a natural result the price steadily rose during 1901 until May 15 in New York it was $18·20 per oz. for ingot platinum, rising to $20@$21 later in the year. In January, 1902, the price continued at $20@$21, but fell in February to $19·50, and in June to $19, a price which prevailed to the close of the year. Best hammered was quoted as follows: January, 82c. per gram; June, 76c.; July, 74c.; August, 73·5c., and December, 72·5c.

Osmiridium is quoted at from $6 to $10 per oz. Practically the price of the metal is determined by the English concern, Johnson, Matthey & Co., which refines a large proportion of the Russian output.

The Production of Platinum in Foreign Countries.

The production of platinum in the world ranges annually between 160,000 and 170,000 Troy ounces, supplied chiefly from Russia, the balance coming mainly from Colombia, South America. Unfortunately, in the latter country the revolutions which have been prevalent in recent years have seriously hindered the development of this important industry. The uses of the metal would be largely increased if it could be obtained in sufficiently large quantity to lower the price. Unfortunately, for many purposes there is no metal to take its place, and the limited supply maintains the price almost equal to that of gold. Russia supplies about 90% of the entire output of platinum in the world.

Australia.—The production of platinum in New South Wales during 1902 amounted to 375 oz., valued at £750, as compared with 389 oz., valued at £779 in 1901, and 530 oz., valued at £1,007 in 1900. The entire output in 1901 and 1902 was derived from the Fifield district, about 322 miles west of Sydney, where it is found associated with gold. The principal workings are at Platina, two miles from Fifield, a deep alluvial lead, containing platinum and gold, extending from near the former place for over a mile in length, and varying from

[illegible] The [illegible] from 60 to 70 ft., through loam, [illegible] [illegible] The platinum and gold occur in [illegible] [illegible] for a few inches above it. The largest nuggets of [illegible] and the largest hitherto found weighs 27 dwt. The [illegible] from ½ to 12 dwt. of platinum, and from 1 to 3 dwt. of gold [illegible]

[illegible] of copper sulphide ore reported to have been obtained [illegible] of Bristol Consolidated, show by analysis [illegible] [illegible] [illegible]

Russia.—The production of platinum in the Urals from 1891 to 1902 is given in the subjoined table:—

Year.	Poods.	Oz. Troy.	Year.	Poods.	Oz. Troy.	Year.	Poods.	Oz. Troy.
1891.....	258	135,874	1895.....	269	141,668	1899.....	368	191,172
1892.....	279	146,934	1896.....	301	158,580	1900.....	332	174,846
1893.....	311	163,787	1897.....	345	181,698	1901.....	380	200,220
1894.....	318	167,473	1898.....	365	192,225	1902.....	446	234,878

The production during 1902 was as follows: Société du Platine, of Paris, 159 poods; Count P. P. Schouwaloff, 99 poods; Prince Demidoff, of San Donato, 53 poods; Kolli, 40 poods; small exploitations, 15 poods; others unknown (placed on the market surreptitiously) 80 poods; total, 446 poods. The entire output was obtained from the Ural, and, with the exception of a few ounces used in St. Petersburg, was exported to London and Hanau.

The Russian sources of platinum supply, which furnish at least 90% of the total consumption of the world, are comparatively limited. The platinum bearing areas extend along the eastern watershed of the Ural Mountains, on Eastern Perm and on the western watershed farther south. Until within a few years the greater part of the Russian output was derived from the district of Nijni-Tagilsk; at present it is obtained in the Goroblagodat and Bisersk districts, 130 miles to the north. The platinum occurs chiefly in the sands of Tura Tagil, Salda, Lala and Loswa rivers on the boundaries of the district of Goroblagodat, as well as the property of Count Schouwaloff and that controlled by the manufacturing works of Bogoslow and Demidoff. The richness of the ore varies from a few milligrams to from 10 to 13 grams per ton. The depth of the platinum sands is about 1 m., while the depth of the overlying turf is usually from 2 to 3 m., although in some cases it is from 10 to 14 m. Generally the platinum grains are small, but occasionally lumps also are found. Apart from the occurrence of the metal in sands, it is found in slight quantities in native gold. Recently a discovery of platinum *in situ* was made on the Martian River in the Nijni-Tagilsk circle, where the metal is found in peridotite, diallage and in serpentine. It has also been found in the gold sands of Birussia. A recent discovery of platinum has been reported on the Gusseva River, a tributary to the Issa River in Western Siberia.

There are two platinum refineries at St. Petersburg which treat a part of the domestic product, the greater bulk of which is exported in the crude state. The crude platinum is sold at from $3,090 to $3,605 per pood (1 pood equals 16·38 kg.); 1·25 pood of concentrates yields 1 pood of refined metal, valued at from $8,240 to $9,270; the cost of refining is $154·50 per pood. The accompanying metals, iridium, palladium and osmium also are recovered. Between 1887 and 1897, 1,833 poods of platinum, costing 29,748,953 fr., were exported to North America and sold for 42,472,276 fr., the net profit being 42·7%. The Franco-Russian Platinum Industry Company, which was organized to free the Russian industry from the control of foreign smelters, did not accomplish its aim, although its efforts resulted in raising the price to be paid by the refiner for the concentrates to $8,240 per pood.

[illegible] of the washing of platinum sands in the Urals will be found in [illegible] of the "Progress in Gold Milling during 1902," under the section [illegible] elsewhere in this volume

Separation.—Levol and Quennessen have devised a scheme for separating [illegible] of the platinum group from one another, a detailed description of [illegible] be found elsewhere in this volume under the section devoted to "Rare [illegible]."

[illegible] investigation of the action of potassium cyanide on platinum [illegible] electrolysis found that platinum is soluble to a slight extent in [illegible] solvent action being greatly augmented with an increase of tempera

Potassium and sodium amalgam have a notable effect, increasing the [illegible] Platinum is dissolved in potassium cyanide (in the absence of [illegible] hydrogen being set free whereas gold and silver are not appreciably [illegible] by potassium cyanide unless oxygen is present

The markings on the surface of platinum after it has been exposed to a [illegible] temperature have been studied microscopically by W. Rosenhain[1] who [illegible] has shown a pattern characteristic of an etched crystalline metal [illegible] the surface with aqua regia the pattern showed more distinctly. He [illegible] the same markings when a new platinum surface was exposed to a high [illegible] in an oxidizing atmosphere, proving that they are not due to the [illegible] of the carbon from the flame as had been believed but solely to the recrys- [illegible] of the metal

[illegible] [illegible] [illegible] [illegible]

POTASSIUM SALTS.

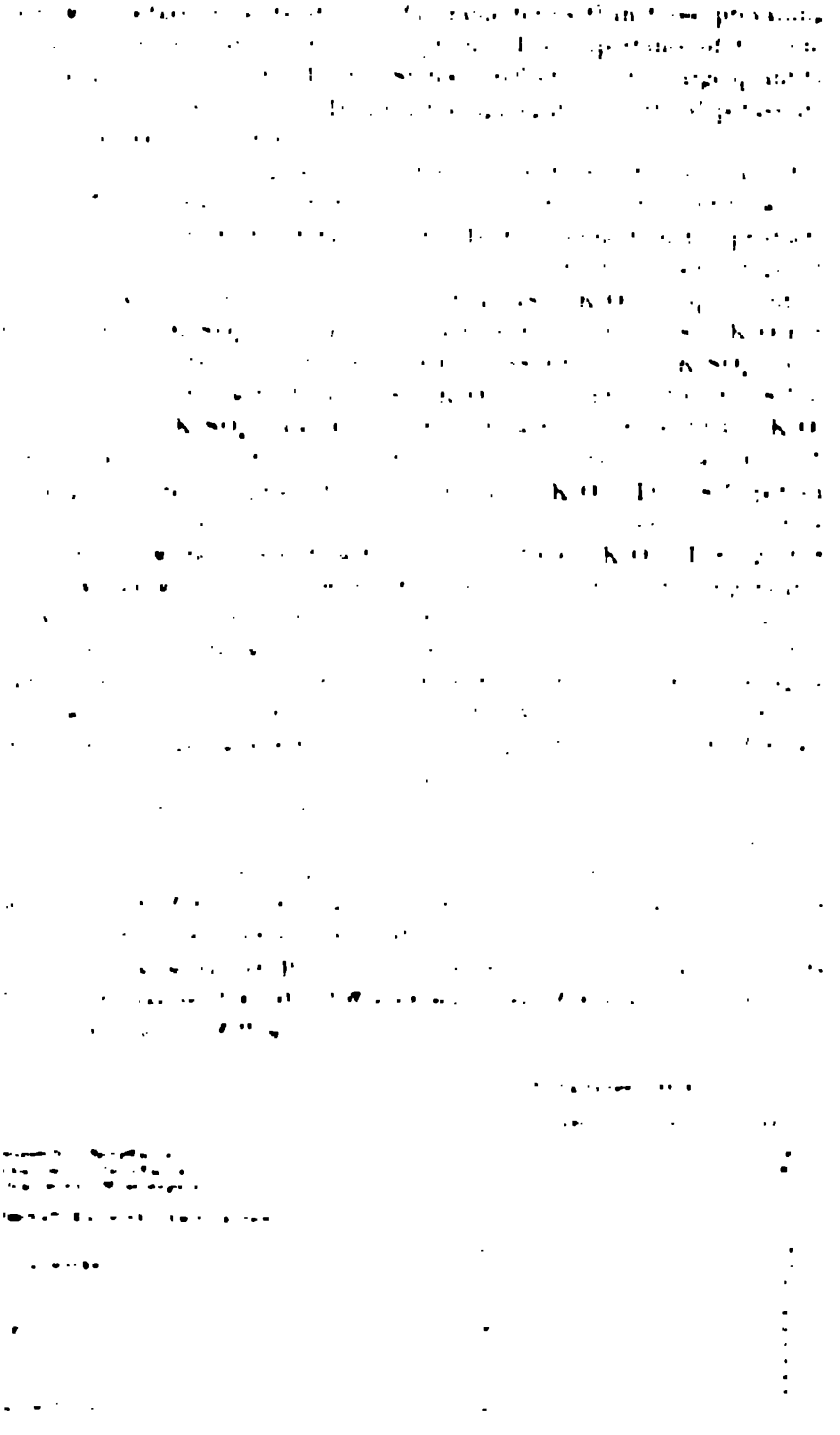
By Joseph Struthers and Henry Fisher.

The United States Potash Co. has examined immense beds of sodium nitrate in Death Valley, Cal., and in other parts of the desert lands of the West. In most cases the deposits contained small quantities only of potassium salts, except where formed by the leaching of bat deposits. As much as 87·5% KNO_3 was obtained in a few small deposits which in time may be consumed locally. Large deposits of ancient volcanic salts were found consisting mainly of potassium sulphate which may be utilized within the next few years to supply the Western demand for this salt. A thorough test of the economic value of these deposits is to be made during 1903. Strong indications exist of the occurrence of beds of salts similar to those at Stassfurt. The proximity to the market and the quantity of salts present are the predominant factors for the future success of the exploitation. It is proposed to continue the exploration work by drilling, as during 1902 the surface deposits only were examined.

Imports and Exports.—The imports of potassium salts into the United States in 1902 were as follows: Potassium chloride, 140,980,460 lb. ($2,141,553); crude potassium nitrate, 10,505,474 lb. ($299,416); potassium chlorate, 1,209,148 lb. ($60,429); all other potassium salts, 92,857,009 lb. ($1,820,585); a total of 245,552,091, valued at $4,321,983, as compared with a total of 231,146,770 lb., valued at $4,268,067 in 1901. The exports of domestic potash and pearl ash in 1902 were 1,408,342 lb., valued at $66,027, as compared with 1,077,605 lb., valued at $52,802 in 1901. The exports of foreign potassium salts in 1902, consisting of potassium chloride, chlorate, nitrate, and other salts aggregated 1,266,125 lb., valued at $59,789, as compared with 633,100 lb., valued at $43,446 in 1901.

The world's supply of potassium salts, with the exception of saltpeter, continues to be derived from Germany, where the production is controlled by the Kali-Syndicate which was organized by all the active mines for the protection of common interests and especially to avoid overproduction. The agreement first entered into in 1879 has been renewed and revised from time to time. The last renewal dates from June 30, 1901, and is to run until December 31, 1904. According to this agreement the marketable products are divided into three classes: (1) Crude salt, that is, potassium and magnesium products direct from the mines, not including boracite; (2) manufactured products, so far as they are prepared in the chemical works connected with the mines; (3) mixed salts, mixtures of crude and prepared salts, for fertilizers.

In 1902, an agreement was made by the Kali-Syndicate with the Virginia-Carolina Chemical Co. and the American Agricultural Chemical Co. to



The statistics of the Stassfurt salt industry for the past five years are g... in the following tables, which were kindly furnished by the Verkaufssyn... der Kaliwerke, Leopoldshall-Stassfurt, commonly referred to in the trade as ... "Kali-Syndicate." Statistics from the beginning of the industry in 1857 ... 1895, inclusive, are given in detail in THE MINERAL INDUSTRY, Vol. VI... pp. 480 and 481.

KALI-SYNDICATE OUTPUT OF CRUDE SALTS OF ALL KINDS. (IN METRIC TON...

Year.	Rock Salt. NaCl.	Carnallite. $KCl, MgCl_2+6H_2O$.	Kieserite. $MgSO_4+H_2O$.	Sylvinite. KCl.	(a) Hartsalz, Schoenite and Kainite.	Boracite. $Mg_7B_{16}O_{30}Cl_2$.	Total.
1898...	291,591	990,998	2,444	94,270	1,120,616	252	2,...
1899...	310,378	1,317,948	2,066	100,053	1,063,195	155	2,...
1900...	(b)	1,697,803	2,047	147,791	1,189,394	233	3,...
1901...	(b)	1,860,189	2,335	190,084	1,432,136	(c)	3,...
1902...	(b)	1,727,672	1,821	188,821	1,532,521	(c)	3,...

(a) Hartsalz, NaCl, KCl, $MgSO_4+H_2O$; Schoenite, K_2SO_4, $MgSO_4+6H_2O$, Kainite, KCl, $MgSO_4+...$
(b) No longer compiled. (c) Not stated.

UTILIZATION OF THE CRUDE POTASSIUM SALTS. (IN METRIC TONS.)

Year.	Carnallite and Rock Kieserite.				Kainite and Sylvinite (a) (including Hartsalz and Schoenite).			
	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.
	Germany.	Elsewhere.			Germany.	Elsewhere.		
1898.....	60,793	7,189	925,461	993,443	722,115	334,111	158,660	1,214,...
1899.....	58,677	4,611	1,256,730	1,320,018	717,637	314,869	131,342	1,163,...
1900.....	55,489	2,869	1,641,493	1,699,851	724,624	375,007	237,554	1,337,...
1901.....	77,862	7,382	1,777,280	1,862,524	850,115	494,220	266,835	1,611,...
1902.....	68,706	5,227	1,655,559	1,729,492	825,170	401,599	244,213	1,470,...

(a) Quantities of sylvinite containing more than 13% potash.

PRODUCTION OF CONCENTRATED SALTS. (IN METRIC TONS.)

Year.	Potassium Chloride. 80%	Potassium Sulphate. 90%	Sulphate, Potassium—Magnesium		Kieserite; Ground and Calcined.	Kieserite in Blocks.	Potash Manure Salt. (a)
			Crystalliz'd 40%	Calcined. 48%			
1898.....	174,380	17,781	914	10,535	728	19,984	54,284
1899.....	180,672	24,656	579	8,459	260	28,216	70,916
1900.....	206,471	31,255	932	12,150	358	28,506	129,963
1901.....	211,421	28,159	751	11,750	361	26,727	140,683
1902.....	181,341	30,202	600	16,884	767	26,809	131,598

(a) Quantities containing 38% potash.

The output of potassium chloride in 1902 was less than during the previous year, due to a smaller domestic consumption, and a decrease in the exports to France, Belgium and Holland. There was, however, an increase in the shipments to the United States. The increase in the production of potassium sulphate was due to the increased exports to the United States and France, the increase more than offsetting the decreased home consumption of this salt. The increase in the production of calcined potassium magnesium sulphate was due to the increased consumption by the United States, Belgium and Holland. Of the output of crystallized potassium magnesium sulphate, none is exported. There was an increase in the production of potash manure salts of 20, 30 and 40% potash contents, caused by Germany and Austria-Hungary consuming more of the 40% product than in 1901, and Norway, Sweden, Denmark, Belgium, Holland, Scot-

Alkaline Hypochlorites and Chlorates.—F. Foerster and E. Müller[1] determined under what conditions the highest efficiency was obtained, when sodium chloride was electrolyzed in the manufacture of sodium hypochlorite and chlorate.

Temperature.	Anodic Current Density.	E. M. F.	The Electrolyzed Solution contained		Current Efficiency.	Watt-Hours consumed per Gram of Hypochlorite Oxygen.
			Hypochlorite Oxygen per Liter.	Bleaching Chlorine per Liter.		
°C.	Amp. sq. cm.	Volts.	Grams.	Grams.	Per cent.	
13	0·017	2·40	4·20	18·6	90	8·40
13	0·017	2·40	5·24	23·2	90	8·35
10	0·070	3·10	6·80	30·1	96	10·94
13	0·170	3·60	5·28	23·4	90	13·20
13	0·170	3·60	8·70	38·5	87	13·50
14	0·170	4·70	5·20	23·0	95	16·60

This table gives the result obtained when a solution containing 280 g. NaCl and 2 g. K_2CrO_4 per liter was electrolyzed at a low temperature. In the last experiment with the solution which contained 100 g. NaCl per liter, it was found that an E. M. F. of 2·2 volts was sufficient to decompose a strong salt solution, and that 7·2 watt-hours was the minimum quantity of electrical energy theoretically required to produced 1 g. of hypochlorite oxygen. In commercial practice, however, about three times this energy is required. In making alkaline chlorate, it was found that the yield was increased when K_2CrO_4 was added to the solution, and in order to keep the salt in the chromate state, HCl was added from time to time.

E. Walker describes G. J. Aitkins' process[2] for the manufacture of hypochlorite. The cell consists of a semi-cylindrical wooden vat, with axis horizontal, 10 ft. long and 2 ft. wide. The inside is lined with sheet lead, and on the sheet lead are placed carbon bricks about 2 in. thick, whose inner surfaces form a semi-cylinder, concentric with the lead and wood. These carbon bricks are cemented together and to the lead by a waterproof carbon cement. A wooden cylinder covered with lead revolves in the vat within an inch of the surface of the carbons, and the space between is filled with the salt solution. The carbon forms the anodes and the current is distributed to them through the lead. The current is led away from the end of the revolving leaden cathode. The total area of the anode surface is about 20 sq. ft. The current used varies from 1,000 to 1,500 amperes at from 3 to 4 volts, and the quantity of 10% salt solution acted on, varies from 500 to 1,000 gal. per hour, the figures depending on the strength of resulting hypochlorite solution required. Preferably the apparatus is worked at the plant where the solution is at once used, as it is not practicable to store and ship the hypochlorite.

No other chemical is required in the vat as the hypochlorite rapidly gives up its oxygen and passes back to common salt again. The salt can therefore be used repeatedly. One of the great advantages of the sodium salt over chloride of lime is that there is no insoluble precipitate, as is the case when chlorine is released from bleaching powder.

The process may be used as a source of chlorine. The addition of sulphuric acid to the hypochlorite solution releases chlorine and oxygen, and forms sodium

[1] *Zeitschrift fuer Elektrochemie*, Jan. 1, 1902, pp. 8-17.
[2] *Engineering and Mining Journal*, Nov. 22, 1902, p. 679.

gas main of vitrified pipe, which carries the chlorine gas to the absorbing towe where it is brought into contact with lime water and lime to form bleaching sol tion ready for use.

Each cathode compartment of the cell may be closed by a cover into which pipe extends and through which the evolved hydrogen gas may be drawn off a

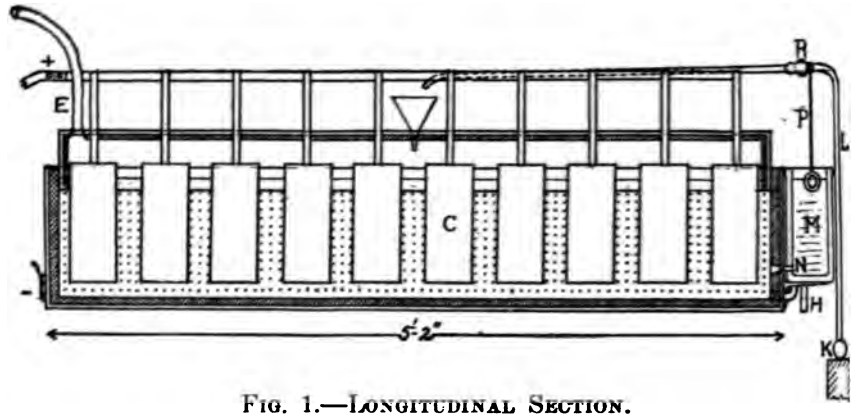


FIG. 1.—LONGITUDINAL SECTION.

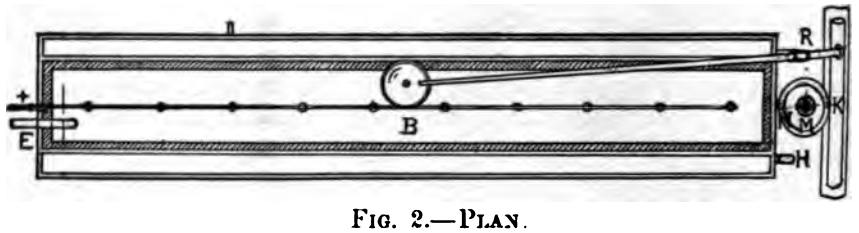


FIG. 2.—PLAN.

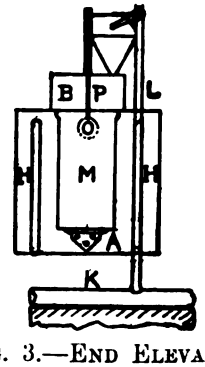


FIG. 3.—END ELEVATION.

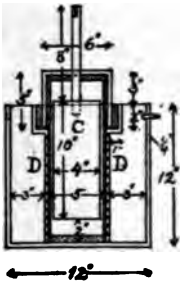


FIG. 4.—CROSS SECTION.

THE MCDONALD CELL.

utilized, although allowed to escape, at present, as is the general practice wit electrolytic chlorine plants.

In Figs. 1 to 3, *H* represents overflow pipes communicating with the cathod compartments and used for carrying off the caustic liquor. These pipes are *elbow form, and* so arranged as to cause the withdrawal of the caustic liquid fro *the bottom of* the cathode compartments, thus preventing escape of the hydrog

QUICKSILVER.

By Joseph Struthers.

The production of quicksilver in the United States during 1902 amounte to 34,451 flasks of 76·5 pounds, valued at $1,500,142, as compared with 29,72 flasks, valued at $1,382,305 in 1901, an increase in quantity of 4,704 flasks an in value of $117,207. Of the total production during 1902, California contribute 29,199 flasks and Texas 5,252 flasks. Oregon, which reported a production of 7 flasks during 1901 from properties undergoing development, made no productio during 1902.

PRODUCTION AND EXPORTS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.			Exports.			Year.	Production.			Exports.		
	Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.		Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Valu
1897..	26,079	965	$910,416	13,173	475	$394,549	1900....	27,855	967	$1,288,851	10,172	353	$485.
1898..	30,493	1,058	1,109,945	12,830	445	440,587	1901....	a29,727	1,031	1,382,305	11,219	389	475.
1899..	28,879	993	1,155,160	16,518	573	609,586	1902....	34,451	1,195	1,500,412	13,247	459	575.

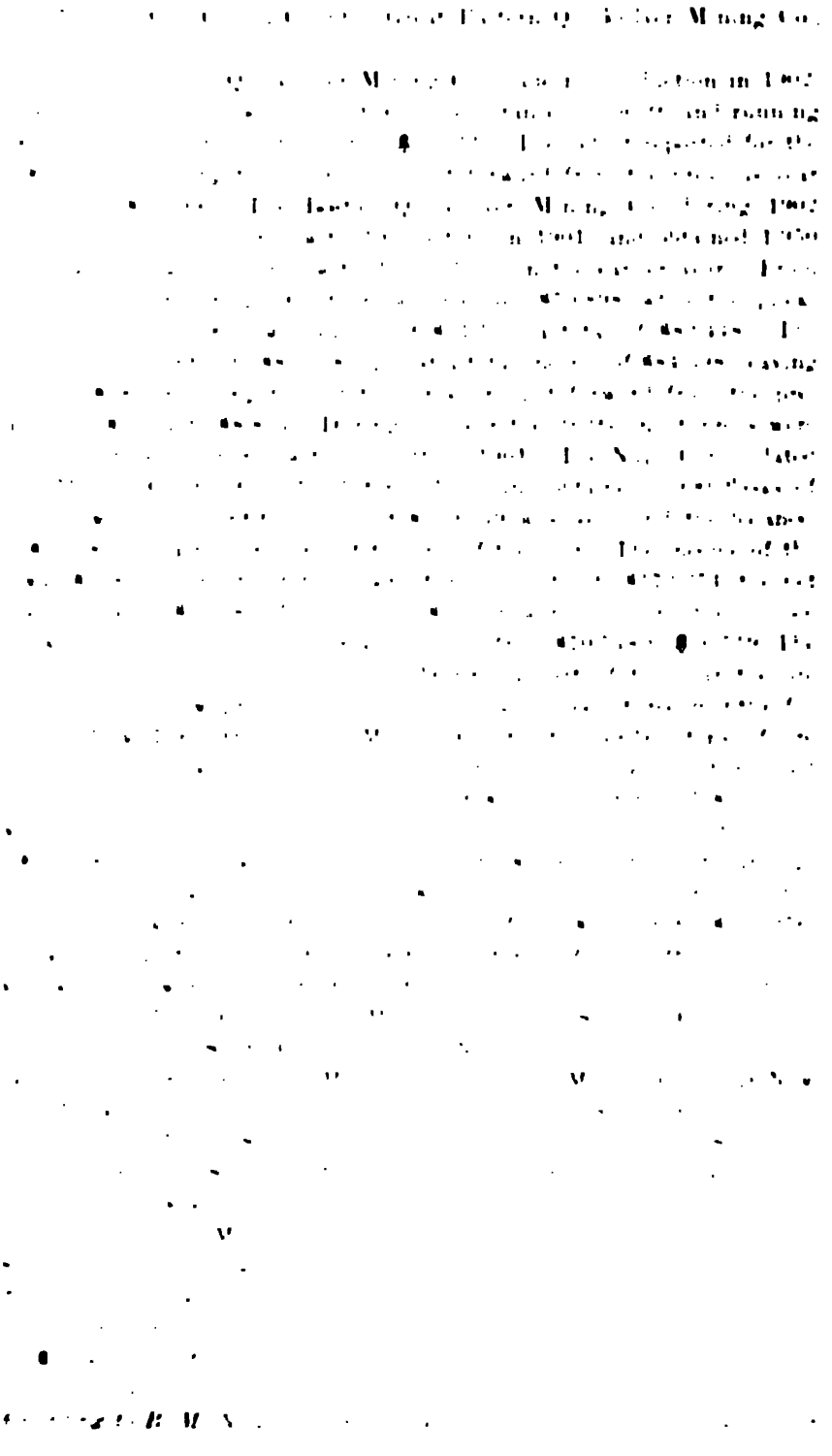
(a) The total production is divided as follows: California, 26,720 flasks; Texas, 2,932 flasks; Oregon, 75 flask

The imports of quicksilver during the past six years were as follows: 1897, 45,539 lb. ($20,147); 18 81 lb. ($51); 1899, 131 lb. ($83); 1900, 2,616 lb. ($1,051); 1901, 1,441 lb. ($789).

Prices.—The average monthly prices of quicksilver at New York and San Fra cisco during 1902 are given in the subjoined table:—

Month.	New York.	San Francisco.	Month.	New York.	San Francisco
January	$48·87	$46·44	August	$48·00	$46·00
February	48·00	47·75	September	48·00	46·00
March	48·00	47·75	October	48·00	46·00
April	48·00	47·75	November	48·00	46·00
May	48·00	46·40	December	48·00	46·00
June	48·00	46·00			
July	48·00	46·00	Average	$48·03	$46·51

California.—During 1902 the mines at San Benito, Napa and Santa Cla counties contributed nearly 20,000 flasks of the total of 29,199 flasks for the enti State. The chief producing companies in the order of their outputs duri 1902 were: New Idria Quicksilver Mining Co., San Benito County; The Quic silver Mining Co., Santa Clara County; Napa Consolidated Mine, Napa Count Karl Quicksilver Mining Co., San Luis Obispo County; Boston Quicksilver Mi ing Co., Napa County; Great Western Mine, Lake County; Empire Consolidat



average mine in California, exclusive of interest and development work, exceeds $35 per flask. Although the greater well-known quicksilver mines are in a measure exhausted, it is practically assured that the future production of quicksilver in the State will occupy a prominent position of economic importance for many years to come. It is not probable that other mines equal in extent to the New Almaden or New Idria will be discovered, but on the other hand there are numerous smaller mines throughout the State which can contribute an output of from 20 to 300 flasks per month. Furthermore, it was the general belief ten years ago that the New Idria, Ætna, Oat Hill, New Almaden, and other prominent mines were practically exhausted, yet the production from these properties still continues to be of much importance.

Classified by counties, the output of quicksilver in California during 1901 and 1902 was as follows:—

County.	1901.		1902.	
	Flasks. (a)	Value.	Flasks. (a)	Value.
Colusa	235	$10,575	1,668	$83,610
Lake	4,395	211,324	2,333	204,058
Napa	7,798	384,176	6,792	289,474
San Benito	4,800	242,300	7,290	306,080
San Luis Obispo	840	41,513	3,312	147,214
Santa Clara	5,220	236,608	5,869	254,260
Salina	.....	.....	42	1,800
Sonoma	2,130	95,850	1,440	74,685
Trinity	1,302	58,668	238	10,251
Total	26,720	1,283,014	29,199	$1,271,532

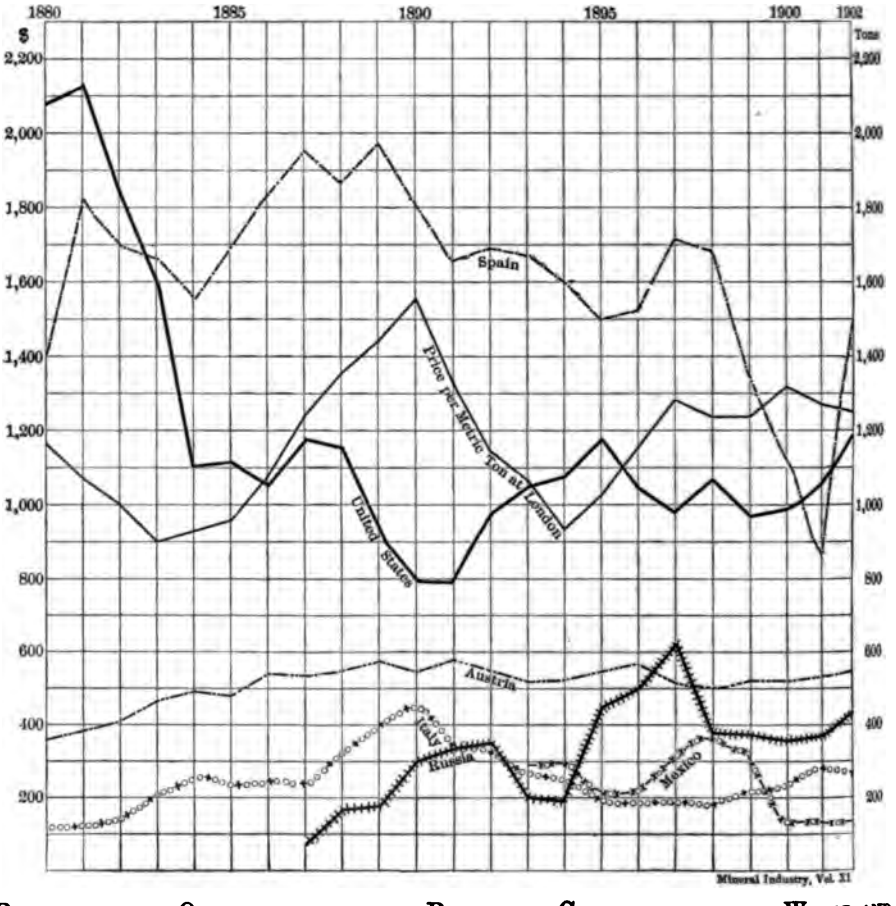
(a) Flasks of 76.5 lb. net.

Oregon.—There was no production of quicksilver in Oregon during 1902, as compared with 75 flasks in the preceding year. Prospecting has been quite active, and considerable development work has been accomplished at several properties. The smelting furnace of the Blackbutte Quicksilver Mining Co., at Blackbutte, which furnished the output during 1901, was not operated during 1902 owing to the delay in rebuilding the condensing plant.

Texas.—The production of quicksilver in Texas during 1902 was 5,252 flasks, valued at $228,620, as compared with 2,935 flasks, valued at $132,438 in 1901, which shows a very active development of the industry in this State; the entire output for both years was made by the Marfa & Mariposa Mining Co., operating at Terlingua, in Brewster County. According to Mr. B. F. Hill, in Bulletin No. 4 of the University of Texas Mineral Survey, cinnabar occurs in the Terlingua mines, either in hard and durable limestone, or in soft and friable argillaceous beds. In the Excelsior claims, the quicksilver occurs mainly as cinnabar, but small quantities of native mercury, calomel and terlinguaite (a new mineral species consisting of mercury oxychloride) are also found. A 10-ton Scott furnace to treat these ores was erected in August, 1900, by Messrs. Norman, Sharpe & Golby, who formed the Marfa & Mariposa Mining Co. in February, 1901, and a second 10-ton furnace was installed early in 1902. The Terlingula Mining Co. built a 40-ton Scott furnace in 1902, which, however, was *closed down* shortly after it was completed. The Colquit Mining Co. is building *a 10-ton* Scott furnace to treat the ore from the Excelsior mines, which occurs in

ment for more than three centuries, about 80,000 tons of ore are produced annually, which is smelted in three furnaces, giving employment to 1,200 men. During 1902 the output from these mines amounted to 510 metric tons.

Australia.—A 50-ton shaft furnace is being erected to treat the cinnabar ore from the mines of the Great Australian Quicksilver Co., at Yulgebar, on the Clarence River, New South Wales. It is estimated that the ore can be mined and smelted at a cost of £2 per ton, which will permit the profitable treatment



PRODUCTION OF QUICKSILVER IN THE PRINCIPAL COUNTRIES OF THE WORLD AND THE PRICE PER METRIC TON AT LONDON.

of material containing as low as 2% Hg. The company had 400 tons of 4% ore mined at the end of 1902 and large bodies of ore containing from 2 to 3% of mercury are being developed. On account of the high cost of labor the ore will not be hand picked, but will be charged to the furnace as mined. Charcoal is used for fuel. The cinnabar occurs in granite which is irregularly dispersed throughout the country rock; it is found also in a concentrated form in channels fairly well defined. The extensive body of quicksilver ore in Ewengar,

naces, of 24, 12 and 2 metric tons capacity per day, and three shaft furnaces of 4 to 6 tons capacity per day. 2. Cornacchino, two Cermak-Spirek furnaces (24 tons and 2 tons) and one shaft furnace (4 to 6 tons). 3. Abbadia S. Salvadore, two Cermak-Spirek furnaces of 24 tons, two of 2 tons, and two shaft furnaces of 6 tons each. 4. Montebuono, one Cermak-Spirek furnace of 12 tons. 5. Cortivecchie, two Cermak-Spirek furnaces building, one of 24 tons, one of 12 tons. The record of all the works from 1893 to 1901, both years inclusive, is as follows:—

Year	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.	Year	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.
	Tons.	%	Tons.		Tons.	%	Tons
1893	14,950	1·9	278	1898	19,201	0·80	153
1894	15,028	1·7	258	1899	29,329	0·70	205
1895	10,504	1·9	199	1900	33,930	0·75	250
1896	13,701	1·8	188	1901	35,000	0·77	271
1897	20,659	0·99	192				

The average value of the quicksilver produced was 4·85 lire per kg. in 1893, and 4·40 lire per kg. in 1894. Since then it has risen gradually but steadily, to 6·50 lire per kg.—$43·50 per flask—the price reported in 1902. Cinnabar is found in the provinces of Tuscany, Florence, Pisa, Lucca, Genoa, Parma, Como, Belluno and Calabria. The ores contain, on an average, 1·2% Hg at Siele, 0·6% at Cornacchino, and 0·4% at Montebuono, as compared with 8% at Almaden, Spain; 0·8% at Idria, Austria; 1% at Nikitowka, Russia, and from 1 to 3% in California. The large Cermak-Spirek continuous furnace has a capacity of 45 tons of ore, but the quantity worked through in 24 hours varies according to the character of the ore. At Siele, it amounts to from 12 to 16 tons, and at Cornacchino, from 20 to 26 tons; while at Montebuono, from 8 to 12 tons of ore are passed through the medium-sized furnace in 24 hours. The temperatures that are obtained in the furnace are as follows: In the combustion chamber, 800° to 900°C.; in the first tier of the roasting-zone, 700° to 800°C.; in the second, 500° to 600°C.; in the third, 500°C.; in the fourth, 360° to 400°C.; in the discharging and collecting passages, 260° to 360°C., and in the drying chamber, which is merely heated from below by the furnace gases, 100° to 200°C. The ore from the mines is sorted into coarse ore over 35 mm. in size, and mixed ore below that size to dust, and then passes direct to the furnace, except that when the proportion of moisture exceeds 7% the ore is dried in summer by the sun's heat, and in winter in specially constructed kilns. The coarse ore, over 35 mm. in size, is treated in stack furnaces, of which the more recent ones are double-stack furnaces. At Siele, in the three-stack furnaces, 18 tons of ore are treated in 24 hours, with an expenditure of 360 kg. of hard charcoal. The results of working with the Cermak-Spirek furnaces, since they have been in proper order, show that with an ore charge containing 529·91 tons of quicksilver, 505·46 tons are recovered, representing a loss of 4·6%. When new condensers are installed, the loss increases to 6%. The mercury absorbed by the plant is, however, recoverable when reconstruction is being carried out.

The cost of the furnaces at the Siele works was as follows: Large Cermak-Spirek furnace, 25,000 fr.; condenser with 6 cast-iron pipes and 300 clay pipes,

TECHNOLOGY.

Review of Analytical Chemistry.—The gravimetric determination of mercury and its separation from antimony, arsenic and copper, according to C. J. Priefeld[1] may be accomplished as follows:—To the solution of the four metals, 30 c.c. of a saturated solution of tartaric acid is added, and the whole thoroughly stirred. KCN in solution is then added gradually until the precipitate which forms at first is completely dissolved, the addition of KCN being continued until from 2 to 3 g. are in excess. The cold solution is then saturated with H_2S, and the precipitate settled, filtered, washed with water containing H_2S, and finally dissolved in a mixed solution of KOH and K_2S. The resultant solution is diluted to 125 or 130 c.c., heated to 70°C. and electrolyzed with a current of $ND_{100}=0.1$ amperes and 2·5 volts, or a cyanide solution may be used for the electrolyte with a current of $ND_{100}=0.07$ amperes and 3·5 volts at a temperature of 65°C. The electrolytic method, however, is not applicable to ores or alloys containing tin.

Spirek Furnaces.—The details of the new Spirek reverberatory furnace are shown in Figs. 1 and 2. Fig. 1 gives the general arrangement in plan of the reverberatory and shaft furnaces and condensers, while Fig. 2 shows a longitudinal vertical section of the reverberatory furnace and condensers. This furnace is supplied with the same charging device as the shaft furnace described in THE MINERAL INDUSTRY, Vol. X., p. 559. The ore falls through the channel *b* to the roasting chamber *a*, where its progress during the treatment is regulated by means of the opening *c*. The fireplace *d* occupies the whole width of the furnace and the flame passing to the roasting chamber, is carried with the quicksilver vapors through the chambers *e* to the condenser. From the chamber *a* the spent ore is collected in the funnels *k*, where it may be withdrawn by means of the levers *l*. The air before entering the roasting chamber is preheated by passing through channels *m* and *n*. The furnace stands upon iron posts and is strengthened with iron plates. For the roasting of quicksilver-lead ores a temperature of from 300° to 400°C. should be maintained.

The Cermak-Spirek furnace which has been described in THE MINERAL INDUSTRY, Vols. VI. and X., is now used at Siele, Comacchino, Montebuone and Abbadia San Salvadore, in the Monte Amiata district, Italy; at Nikitowka, Russia, and at Taghit, Algeria. There are in course of construction also four furnaces at Almaden, Spain, and one at Cortivecchia, Italy; while one furnace has been built at Ponte di Nossa, Italy, for the calcination of zinc ores.

At the Taghit mine in Algeria, owned by Laguchee Co., of Paris, two furnaces have been erected. Of these one is a Cermak-Spirek roasting and calcining furnace of 6 tons daily capacity (ores finer than 35 mm. in size) and the other a Spirek shaft furnace to treat 6 tons of ore per day, of a size greater than 35 mm. These furnaces treat the zinc ore for quicksilver in the winter when there is enough water to cool the condensers, treatment of the calcined ore free from quicksilver being reserved for the summer months, when the condensers are disconnected. After the extraction of the quicksilver the calcined ore is sold. For the extraction of the quicksilver a temperature of from 400° to 600°C. is required, while that for calcining is 1,100°C.; both processes, however, are worked in the

[1] Dissertation for the degree of Doctor of Philosophy, Columbia University, 1903.

and one duplex shaft furnace of 12 tons per day, together with channel, chimney and engines, were as follows: Fireproof material and terra cotta for furnace and condensers, 21,703 fr.; ironwork, 27,586 fr.; woodwork for condensers and chan

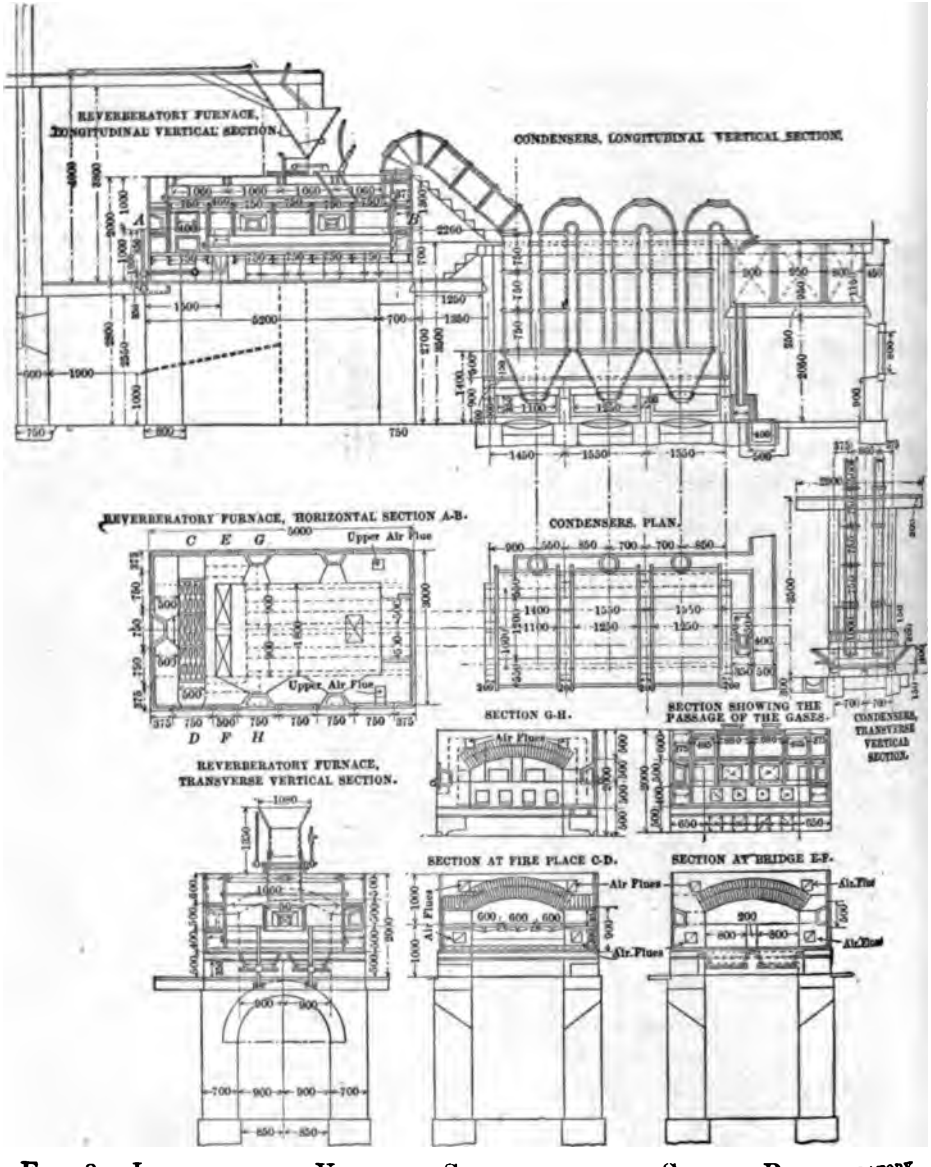
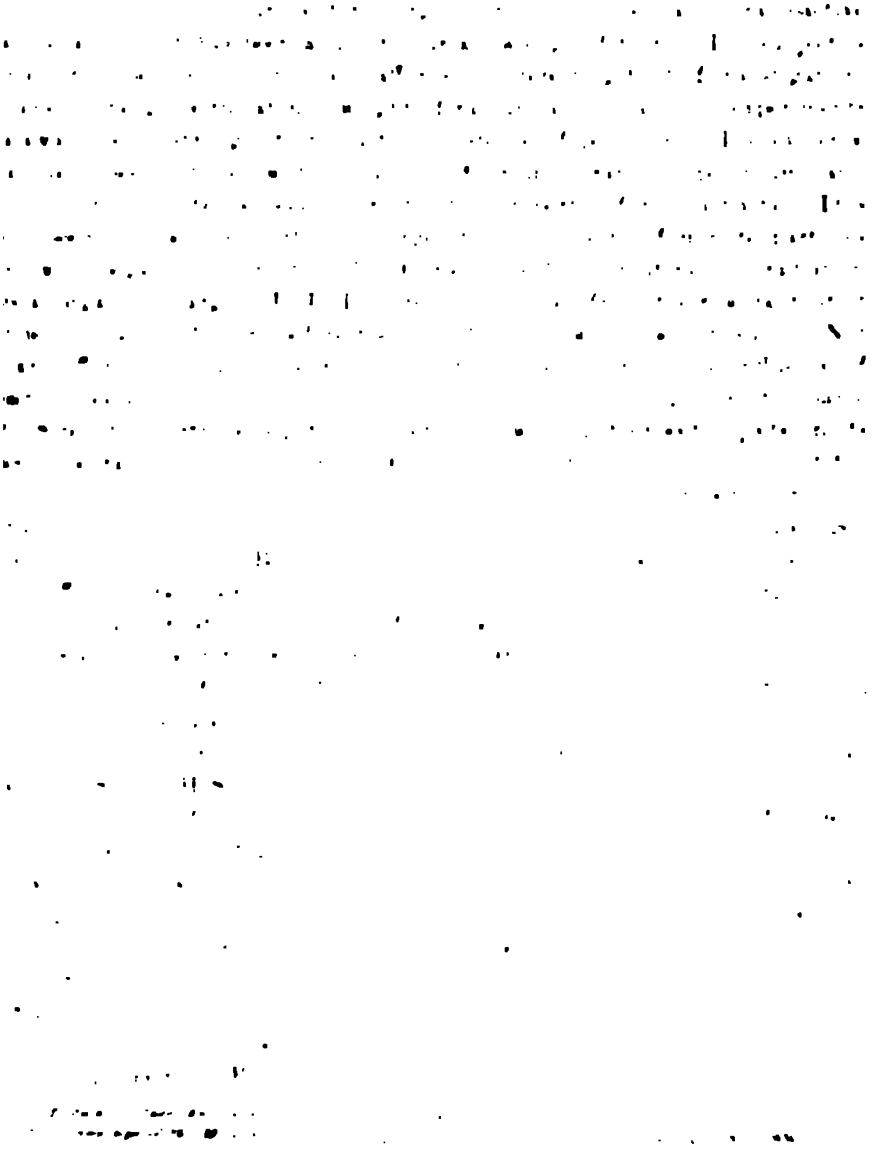

REVERBERATORY FURNACE, LONGITUDINAL VERTICAL SECTION.
CONDENSERS, LONGITUDINAL VERTICAL SECTION.
REVERBERATORY FURNACE, HORIZONTAL SECTION A-B.
CONDENSERS, PLAN.
Upper Air Flue
SECTION G-H.
SECTION SHOWING THE PASSAGE OF THE GASES.
CONDENSERS, TRANSVERSE VERTICAL SECTION.
REVERBERATORY FURNACE, TRANSVERSE VERTICAL SECTION.
SECTION AT FIRE PLACE C-D.
SECTION AT BRIDGE E-F.
Air Flues

FIG. 2.—LONGITUDINAL VERTICAL SECTION OF THE SPIREK REVERBERATORY FURNACE AND CONDENSERS, WITH OTHER SECTIONS.

nels, 6,636 fr.; materials for foundations, channel and chimney, 11,620 fr.; engines, including blower, 8,000 fr.; total, 78,539 fr. (sic).

The Spirek furnace is being introduced into the United States by the concern of *Thomas J.* Ryan and Horejse-Spirek, of New York.

THE RARE ELEMENTS



The cheap production of metallic calcium is very important to the industrial world. It would find wide application as a reducing agent and to remove impurities from iron. Heretofore, however, the cost has prohibited its use even for experimental work. Recent improvements in the electrolysis of the fused salt seem to have overcome the earlier difficulties and it is stated that the metal can now be produced at a cost of 45 cents a pound.

The methods of the different investigators, Borchers and Stockem,[3] K. Arndt,[4] and Ruff & Plato[5] are much the same. All use internal heating and employ a large carbon anode and small iron cathode. The electrolyte is $CaCl_2$, containing a small amount of CaF_2. The metal must be removed as formed, otherwise it gradually recombines with the chlorine liberated at the anode. Both Ruff and Borchers describe a subchloride having the probable formula CaCl, which is formed in the process. This salt is red in color.

The use of electrodes of calcium carbide in arc lamps has been patented by Robert Hopfelt. They are covered with waterproof compound or sheathed with aluminum. He claims that metallic carbides give a more powerful light than carbon.

Cerium.—By passing a current of from 30 to 40 amperes at a pressure of from 12 to 15 volts for two hours through fused anhydrous cerium chloride, Muthmann[6] obtained from 23 to 29 g. cerium 99·92% pure. He describes the metal as harder than lead but soft enough to cut with a knife. It is slightly attacked in dry air, easily in moist, slowly by cold water, more rapidly by hot water; and easily dissolves in acids with evolution of hydrogen.

Sterba[7] has prepared the oxycarbide of cerium $2CeO_2.CeC_2$, sp. gr. 4·8, by heating CeO_2 with insufficient carbon in the electric furnace. He has also prepared[8] the silicide, $CeSi_2$, from silicon and CeO_2 in the electric furnace. The crystals are small and of steely luster. The silicide is acted on slowly by water. Fluorine attacks it in the cold; Cl, Br, I and HCl gas when heated. The alkalies are without action in the cold. It burns at red heat in oxygen, also on boiling with sulphur or selenium.

E. Baur[9] finds that cerous sulphate solution containing potassium carbonate when shaken in the air, gives cerium peroxide and also some ceric salt. R. Meyer and Koss[10] separate cerium from mixtures of the rare earth by repeated boiling with magnesium acetate.

C. R. B. Bohm[11] has studied the separation of the cerite metals by use of fractional precipitation with chromic acid. For successful separations it is necessary that the solution of the earths and chromate should be very dilute; that the solution must be kept boiling and that the precipitate be finely divided and thoroughly stirred to secure intimate contact with the solution.

Germanium.—This element, which was predicted by Mendelejeff and occupies the place below silicon in the periodic system, was discovered in the silver ore argyrodite by Winckler in 1886.

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[3] *Zeitschrift fuer Elektrochemie*, 8, 40, 757, 1902.
[4] *Ibid.*, 8, 861.
[5] *Berichte*, 35, 17, 3612.
[6] *Annalen*, 320, 231, 1902.
[7] *Comptes rendus*, 134, 1056, 1902.
[8] *Ibid.*, 135, 170, 1902.
[9] *Zeitschrift fuer Anorganische Chemie*, 30, 251, 1902.
[10] Berichte, 35, 672, 1902.
[11] Zeitschrift fuer angewandte Chemie, 15, Dec. 13, 1902.

orange colored solution of ruthenate. This, treated with chlorine as above, di over but is reduced to ruthenium when heated with alcohol and potassium chlori Palladium forms sodium palladate. This does not distil with chlorine b when neutralized with HCl, and KCl added, ruby red crystals of potassi chloropalladate separate. Iridium gives a blue solution of the basic irid $IrO_2.2Na_2O$, which, when treated like the palladium solution, yields bla crystals of chloriridate. Sodium platinate is not soluble in water, but on tre ment with HCl, the platinum is identified as the chloroplatinate. Rhodi remains insoluble as the dioxide and sesquioxide, of which the former is solu ble in HCl and on further treatment with NaCl gives a rose-colored solution of $6NaCl.Rh_2Cl_6$.

Neodymium.—Muthman[19] has prepared metallic neodymium by electrolysis of fused neodymium chloride containing barium chloride, using carbon electrodes and a current of 35 amperes at a pressure of 25 volts. The metal is silver white, harder than cerium (see under the section *"Cerium"*), more easily oxidized and has a higher melting point. At its melting point it attacks porcelain with the formation of the silicide. It dissolves readily in acids, and unites with bromine to form the tribromide and with iodine when heated. When electrolyzed with metallic salts it gives alloys. C. Malignon[20] has prepared the anhydrous chlorides of neodymium, praseodymium and samarium by heating to 180°C. in a current of HCl. These anhydrous salts dissolve in water with the evolution of heat and in alcohol.

Nitrides.—Guntz[21] suggests the preparation of metallic nitrides by heating the metallic chloride with the nitride of lithium.

$$Li_3N+3MCl=M_3N+LiCl.$$

According to Moeser and Eidmann[22] boron nitride can best be prepared by passing NH_3 over strongly heated B_2O_3 and Ca_3PO_4. Upon washing the product with HCl, BN 80 to 90% pure may be obtained. Boron nitride is a strong reducing agent.

Osmium.—Tests on osmium lamps show that the osmium filament is in many respects superior to carbon. A high efficiency is maintained throughout the life of the lamp. In Berlin, 300 lamps were used on street lighting circuit with entirely satisfactory results. The efficiency is about 1·5 watts per candle power. As yet they have been used only on circuits of 50 volts or less which necessitates burning in series.

Palladium.—The recent discovery of platinum and palladium in the copper ores of the Rambler mine near Laramie, Wyo., seems to promise a larger supply of palladium than has heretofore been known. The palladium occurs as the diarsenide $PdAs_2$, and corresponds to the mineral sperrylite. At present the use of palladium is confined almost entirely to the manufacture of scientific instruments, but in general, the alloys have not been carefully studied.

Polonium.—The radioactive bismuth found in pitch blende, has been considered by many investigators to contain no new element, polonium being

[19] *Annalen*, 320 (2), 231, 1902.
[20] *Comptes rendus*, 134, 1308.
[21] *Comptes rendus*, 135, 738, 1902.
[22] *Berichte*, 35, 585, 1902.

Silicon.—Moissan and others have prepared a number of new silicides. Lithium and silicon[28] heated in a vacuum give Si_2Li_6. The silicide consists of small indigo crystals having a sp. gr. of 1·12. It unites violently with the acids and water forming with the latter H and Si_2H_6. Liquid Si_2H_6[29] has been prepared by Moissan by cooling down with liquid air the gaseous products of the decomposition of magnesium silicide with HCl. It has a melting point of 52°C. and a freezing point of 138°C. It burns spontaneously in the air and is a strong reducing agent. When Si_2H_6[30] is decomposed by an electric spark H and Si result. The silicon appears in long filaments and shows remarkable reducing properties, reducing copper sulphate in the cold. Vanadium silicide[31] made by heating V_2O_5 and silicon in the electric furnace, has a formula VSi_2. It is not attacked by acids, except HF, nor by alkalies. Lebeau[32] describes three crystallizable silicides of cobalt; $SiCo_2$, SiCo and Si_2Co, which he has prepared in the electric furnace. The last-named of these is new. It has a hardness of from 4 to 5, and is not easily acted upon by acids except HF. Calcium silicide[33] has a formula $CaSi_2$ and consists of grayish crystals, sp. gr. 2·5, which are decomposed by water and acids giving H but no silicon hydride.

Strontium.—Guntz, using a mercury cathode, electrolyzed a solution of strontium chloride, and obtained metallic strontium from the amalgam by heating in vacuum to full redness. The metal is white, very like barium, but fuses higher and does not so readily form the metal ammonium. By electrolysis of fused $SrCl_2$ in a vessel composed of a carbon cylinder forming the anode and arranged with an insulated bottom pierced by a cathode of iron, Borchers and Stockem[34] obtained globules of pure metallic strontium, which sank to the bottom of the bath.

Tantalum.—Metallic tantalum has been prepared by Moissan[35] by heating Ta_2O_5 and sugar carbon in the electric furnace. The metal had a crystalline fracture and contained only 0·5% C. It scratches glass, has a sp. gr. of 12·79 and fuses in a powerful arc. Chlorine begins to attack it at 150°C., and at 250°C. the reaction takes place with incandescence. The chloride sublimes as orange yellow needles. Bromine acts on tantalum only at red heat and iodine not at all at 600°C. At 600°C. the metal burns in oxygen. HCl gas attacks it with the evolution of hydrogen but the simple acids do not attack it except H_2SO_4, which does so slowly. It dissolves, however, in a hot mixture of HF and HNO_3. With KOH it gives off hydrogen and forms the alkaline salt. Tantalum will reduce PbO, PbO_2, MnO_2 and $HgCl_2$, being more strongly reducing than neobium, which it greatly resembles.

Terbium.—The existence of this element has often been disputed. Marc[36] after exhaustive researches reaches the following conclusion: Terbium oxide is deep brown, ocher color. There is also a lower oxide which is colorless. The earths previously described as terbia earth were mixtures of yttria and a heavier earth, colored by terbium oxide. Terbium has probably an absorption spectrum

[28] *Comptes rendus*, 134, 1083.
[29] *Ibid.*, 134, 569.
[30] *Ibid.*, 134, 1552.
[31] *Ibid.*, 135, 78.
[32] *Comptes rendus*, 135, 475.
[33] *Ibid.*, 134, 503.
[34] *Zeitschrift fuer Elektrochemie*, 8, 40, 759.
[35] *Comptes rendus*, 134, 211.
[36] *Berichte*, 35, 2382, 1902.

[illegible]

these filaments are superior to carbon, both in the quality of the light and that they may be used on circuits up to 500 volts. Carbon filaments have not been used successfully at this voltage. The titanium light is much whiter than carbon and is very soft to the eye. Uranium carbide gives a yellow light. Its use is suggested for outside lights of high candle power.

Auguste J. Rossi has been studying the metallurgy of titanium. Although it is usually considered that ores containing titanium are very difficult to work in a blast furnace, he states[48] that he has been able to treat ores of this character easily. The pig iron produced from them, while containing little titanium, is of superior quality. The addition of titanium in minute quantities to iron and steel increases tensile strength enormously. Titanium has a great affinity for nitrogen and Rossi suggests that the presence of titanium in iron and steel acts not only as a dioxygenizer, but also takes out nitrogen which is present in minute quantities. The making of titanium alloys is described in THE MINERAL INDUSTRY, Vol. IX. In this connection mention should be made of the large deposits of rutile which occur in Virginia.[49]

Uranium and Vanadium.—The use of uranium and vanadium in the manufacture of steel is still in the experimental stage and small quantities only are produced. The total production of uranium ores in the United States during 1901 was 375 tons, obtained chiefly from Colorado. The presence of vanadium in steel is said to render it so hard that by its use armor plates may be reduced to one-half the ordinary thickness. One peculiarity of vanadium steel is that it does not acquire its maximum hardness through tempering but by reheating from 700°C. to 800°C. In consequence of this property, the cutting tool of a planer made of vanadium steel continued to cut without being injured by heat, even when heated to redness. This property would be of great importance in the making of armaments and heavy projectiles. When the projectile strikes armor plate, the temperature is raised even to fusion so that if the presence of vanadium prevents the loss of hardness, and consequently of sharpness, the penetrative power would be greatly increased. The influence of vanadium in steel is due to its strong affinity for oxygen, its presence insuring the removal of the last trace of iron oxide. The tendency of steel to crack and rupture is attributed to traces of iron oxide which can be removed in no other way.

Yttrium and Ytterbium.—Dennis and Dales[50] after trying many methods for separation of the metals of the yttrium group, find that unusually rapid separations of these earths may be effected with ammonium carbonate and acetic acid. Fractional solution of the hydrates with saturated ammonium carbonate gives rapid separation and this, combined with fractional precipitation of the carbonate solution with acetic acid, gives striking results; erbium and terbium concentrate in the first fraction and ytterbium comes down last.

Cleve has studied the chemistry of ytterbium. He finds it to be a purely trivalent element forming characteristic compounds, as the gold double chloride, the periodate $YbIO_3$, and the basic carbonate $Yb(OH)CO_3$. Even in acid solution it forms the neutral orthophosphate $YbPO_4$. He suggests that ytterbium

[48] *Journal of the Franklin Institute*, 64, 241. [49] *Engineering and Mining Journal*, March 8, 1902.
[50] *Journal of the American Chemical Society*, 24, 40.

...m is classed with yttrium, erbium and gadolinium on a basis of the similarity of the potassium cyanides all of which crystalize alike, apparently with 18 molecules of water. A new mineral, Hussakite, is reported from Minas Geraes, Brazil, which contains as much of the yttria earths, as Y_2O_3 13.13%, Er_2O_3 14.87%, ... It seems to be the parent mineral of xenotime.

... and Huller[1] separate iron and zirconium quantitatively by treating in a current of hydrogen. The method is as follows. The metals are precipitated as hydrates with NH_4OH a second precipitation being necessary to bring down all the zirconium, and weighed as oxides; the iron is reduced to metal in a current of hydrogen at red heat. Since none of the zirconium oxide is reduced, a second weighing enables the amount of iron to be calculated.

... the Nernst lamp furnishes the best electric light yet produced. The efficiency is stated to be on a parity with the enclosed arc and double the ... incandescent lamp. Huller[2] publishes a number of tests on these lamps. The life of the glower he finds to be about 200 hours and the average candle power per watt. The chief cost there is in the renewal of the glower which brings maintenance to a much higher figure than with arc or filament lamps. These lamps will find a wide use where large candle power is required and cost is not a factor.

[1] ... [2] ...

SALT.

By Joseph Struthers.

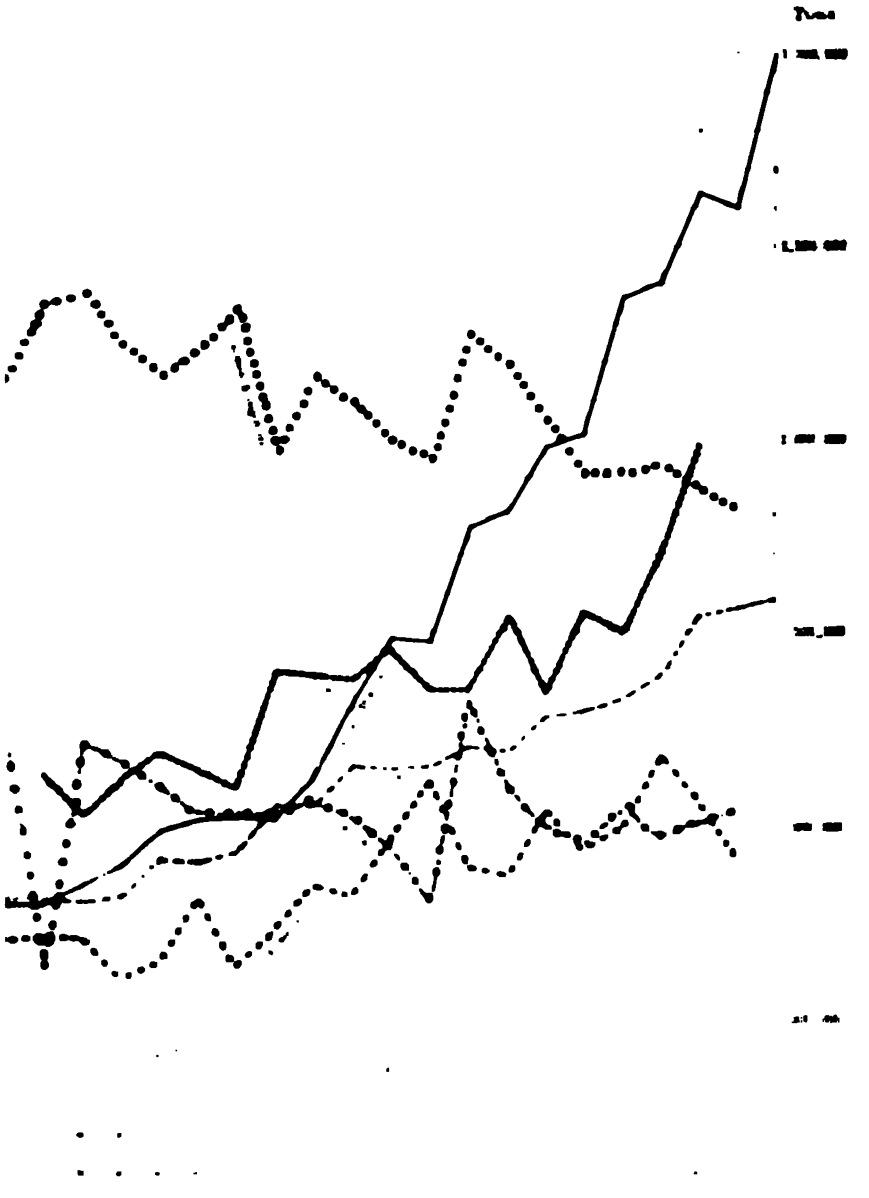
The total production of salt in the United States during 1902 including that used for the manufacture of alkali and heavy chemicals amounted to 23,849,221 bbl., valued at $5,668,636, as compared with 20,566,661 bbl., valued at $6,617,449 in 1901. The leading salt producing States rank in the order of production and percentage of output during 1902 as follows: Michigan, 8,131,781 bbl., 34·1%; New York, 8,523,389 bbl., 35·8%; Kansas, 2,158,486 bbl., 9·1%; and Ohio, 2,109,987 bbl., 8·9%. These four States furnished 87·9% of the total quantity of salt produced in the United States during 1902.

PRODUCTION OF SALT IN THE UNITED STATES. (IN BARRELS OF 280 LB.)

Year.	California	Illinois.	Kansas. (a)	Louisiana.	Michigan (c)	Nevada.	New York. (c)	Ohio, W. Virginia and Penn.	Utah.	Other States. (c)	Total Barrels.	Total Short Tons.
1898.....	667,293	57,796	1,810,809	120,300	6,728,005	5,325	7,625,809	1,044,086	121,429	515,592	18,756,394	2,625,895
1899.....	590,386	54,500	2,172,000	357,143	6,699,060	5,900	7,726,172	1,215,000	448,132	594,555	19,861,948	2,780,672
1900	455,271	55,000	2,350,000	396,744	6,845,685	5,786	8,123,550	1,698,286	267,857	560,550	20,758,729	2,906,222
1901 (b)....	601,659	99,700	2,087,791	451,430	7,729,641	13,781	7,286,320	1,385,257	334,484	569,092	20,566,661	2,879,433
1902 (b)....	682,660	90,009	2,158,486	399,163	8,131,781	14,829	8,523,389	2,318,579	417,501	1,112,894	23,849,221	3,338,891

(a) Output in 1900 is estimated. (b) Through the courtesy of the United States Geological Survey. (c) Includes salt used for the manufacture of alkali.

The total output of salt in the United States during 1902 is classified as follows (in barrels of 280 lb.): Table and Dairy, 2,027,798; Common, Fine, 6,692,587; Common, Coarse, 1,571,137; Packers, 466,987; Solar, 1,172,484; Rock, 2,889,836; Milling, 127,521; Other Grades (including salt in brine used for the manufacture of sodium salts), 8,900,881; total, 23,849,221. The large increase in the production of salt in the United States during 1902 has resulted from the continuance of general conditions of prosperity throughout the country, an increase which would have been much greater had it not been for the shortage of fuel due to the anthracite coal strike. In spite of this hindrance, however, the production of salt during 1902 is the largest quantity yet recorded for any one year. This great development of the industry from the output of 5,961,060 bbl. in 1880 to 23,849,221 bbl. in 1902, has progressed almost continuously, there being but two years in which the annual production did not exceed that of the year immediately preceding, *i.e.*, 1889, with a decrease of 50,000 bbl. (*equivalent to 0·6%*) and 1900, with a decrease of 300,000 bbl. (equivalent to *approximately 1·5%*). As a natural result of this enormous increase, the business has



THE WORLD'S PRODUCTION OF SILVER, GOLD, AND COAL

fornia, and as a development of this change in business methods it is interesting to note that the combination of salt producers in California, which maintained the price of coarse salt at $18 per ton, was formally indicted by the Federal Grand Jury, and enjoined by the United States Circuit Court from forcing prices above a reasonable compensation for the cost of manufacture. Also, that the National Salt Co. of New York, the largest individual producer of common salt, was declared insolvent on Sept. 30, 1902, and was placed in the hands of a receiver.

Imports and Exports.—The imports of salt entered for consumption during 1902 were 369,528,186 lb. ($647,554), as compared with 403,465,946 lb. ($676,324), in 1901; the exports of domestic salt amounted to 10,188,771 lb., ($55,432), in 1902, as compared with 18,865,247 lb. ($86,414), in 1901.

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (*a*) (*g*) (IN METRIC TONS AND DOLLARS.)

Year.	Algeria.		Austria. (*d*)		Canada.		France.		Germany.	
1897.....	23,222	$78,058	331,084	$10,224,576	46,584	$225,730	948,000	$2,239,823	1,306,684	$3,838,496
1898.....	21,300	86,000	341,959	10,607,799	51,796	234,520	999,283	2,115,120	1,370,341	3,954,743
1899.....	17,378	67,300	342,059	10,124,700	51,796	234,520	1,193,532	2,506,832	1,432,181	3,978,750
1900.....	18,325	76,288	330,277	9,957,173	50,296	279,458	1,088,634	2,415,973	1,514,097	4,627,500
1901.....	18,518	79,976	333,238	9,888,231	58,927	262,328	910,000	2,012,800	1,563,811	5,064,750

Year.	Greece.		Hungary. (*d*)		India.		Italy. (*e*)	
1897.....	20,421	$308,357	171,711	$5,375,788	937,888	$975,260	31,526	$117,504
1898.....	25,270	363,600	178,551	5,679,584	1,045,828	1,485,702	29,745	120,715
1899.....	37,125	579,150	182,198	5,479,782	977,240	1,324,748	28,842	64,418
1900.....	22,411	336,165	189,363	5,456,600	1,021,426	1,146,363	29,221	128,617
1901.....	23,079	351,700	184,088	5,668,200	1,120,187	1,405,682	33,744	131,786

Year.	Japan. (*f*)	Russia.		Spain.		United Kingdom.		United States.	
1897.....	621,731	1,551,894	$2,711,077	508,606	$1,159,294	1,983,949	$3,104,490	2 009,695	$3,896,556
1898.....	646,719	1,505,600	2,566,906	479,358	1,025,682	1,908,723	3,100,575	2,382,197	4,753,664
1899.....	590,433	1,681,362	2,767,168	598,108	1,091,133	1,945,581	3,280,870	2,522.610	5,437,941
1900.....	669,694	1,968,005	3,124,000	450,041	834,535	1,873,601	3,059,600	2,651,278	6,944,608
1901.....	(*c*)	(*c*)	(*c*)	345,063	599,934	1,812,180	2,864,950	2,612,204	6,617,449

(*a*) From the official reports of the respective countries. For Austria, Hungary, Russia, Spain, and the United States, the production of all kinds of salt is given; Germany, rock salt and common salt; Greece, sea salt; France, rock and sea salt; Algeria, sea and rock salt; Italy, rock and salt from brine; United Kingdom, rock and brine salt; India, salt which is liable to British salt tax only, and does not include salt made in certain native States. (*b*) Not reported in the official statistics. (*c*) Statistics not yet published. (*d*) The high valuation of salt in Austria and Hungary is due to the government monopoly of production and high taxation. (*e*) Rock and brine salt only. About 400,000 tons of sea salt is made annually. (*f*) No value given. (*g*) In addition in 1900, Australasia produced 34,095 metric tons ($188,145); Cape Colony, 11,833 metric tons ($158,800); Ceylon, 11,079 metric tons ($15,900); Cyprus, 3,175 metric tons ($21,515); Peru, 15,000 metric tons ($275,000); Switzerland, 49,284 metric tons; Tunis, 9,160 metric tons ($64,120); Turks and Caicos Islands, 55,615 metric tons ($117,460).

SILICA

Under this caption are grouped the various forms of silica that have a commercial or industrial value, including diatomaceous earth, tripoli, sand, silica brick, fire clay, and the materials used in the manufacture of grindstones and whetstones. Material for the following paragraphs will be found under the respective headings in the text.

Diatomaceous Earth. Deposits of this material have been found in the northwestern corner of Pinal County. According to Prof. W. P. Blake, [illegible] deposits are [illegible] Maricopa and Pinal counties. [illegible] the most [illegible] the [illegible] the [illegible] a [illegible] Diatomaceous earth [illegible] Arizona [illegible] Wickenburg [illegible] Yuma [illegible] Wellton [illegible] Gila [illegible] Bouse [illegible] Parker [illegible] Colorado [illegible] Bill Williams [illegible] Mohave [illegible] Kingman [illegible] Hackberry [illegible] Peach Springs [illegible] Diatomaceous earth [illegible] Arizona

Silica.—The manufacture of apparatus for use in the chemical and electrical industries from fused quartz is carried on at Hanau, Germany. The material has a smaller coefficient of expansion than ordinary glass, so that it is little effected by changes of temperature, and besides is resistant to the action of acids, and is said to possess other advantages which make it valuable for technical purposes. Ordinarily, when quartz is subjected to high heat in the electric furnace, it is reduced and volatilized, but by blowing a current of air into the crucible volatilization ceases and the mass fuses. The same result may be obtained in a Moissan furnace of the reverberatory type, by placing the material below the arc and allowing the heat to be radiated upon the charge. In this way it is possible to fuse quartz around a core of carbon without reduction, and thus a rough tube may be formed which can be drawn and blown. Quartz glass is well adapted for vessels in which acids are concentrated, for accumulator cells, electrolytic tanks, and for pumps handling corrosive liquids.

The output of crystallized quartz in the United States during 1902 amounted to 13,904 short tons, valued at $117,423, as compared with 14,050 short tons, valued at $41,500 in 1901.

Siloxicon.—A new refractory substance, to which the trade name siloxicon has been given, was first made in 1902. The material possesses refractory properties that may make it valuable for crucible manufacture, furnace linings, etc. It is composed of silicon, carbon and oxygen in proportions varying between the limits represented by Si_2C_2O and Si_7C_7O. For typical material the formula may be given as Si_2C_2O, which is formed according to the following equation: $2SiO_2+5C=Si_2C_2O+3CO$. It is of grayish green color and has a density of 2·74. Tests show that it is neutral, insoluble in molten metals and unaffected by any acids except hydrofluoric acid which seems to attack it slowly. When heated above 2,674°F. in presence of free oxygen, siloxicon decomposes according to the following equation $Si_2C_2O+7O=2SiO_2+2CO_2$. If the material is in the form of a brick or other molded mass the reaction takes place on the surface producing a vitreous glaze which in most cases is tinged light green from the presence of iron. In the absence of free oxygen no decomposition occurs, and the temperature may be raised to the point of the formation of carborundum or approximately 5,000°F. before any change takes place, when it breaks up in carborundum and other substances probably as follows: $Si_2C_2O=SiC+Si+Co$.

Siloxicon is made in a furnace somewhat similar to that used in the manufacture of carborundum, although of larger proportions, and worked at a lower temperature. The furnace is about 30 ft. long, 9 ft. wide and 5 ft. high, and has multiple cores, whereas the carborundum furnace has a single core. The furnace is filled with a mixture of sand and coke, to which a certain amount of sawdust is added in order to secure the necessary porosity to allow of free escape of the carbon monoxide gas. Through the center of the mixture pass two or more large flat cores of granular carbon, the cores being so proportioned that they give a very great radiating surface. The temperature of the cores is adjusted so as not to go to such a high temperature as to reach the point of decomposition.

SODIUM SALTS.

By Joseph Struthers and Henry Fisher.

[illegible] of soda and sodium salts in the United States for the year [illegible] were stated at [illegible] metric tons, as compared with [illegible] metric tons in [illegible]. These figures include the production of soda ash, caustic soda, [illegible] and bicarbonate all reduced to the basis of 58% alkali; the output of soda ash being about [illegible] tons, of caustic soda [illegible] tons, and of sodium [illegible] tons.

The [illegible] in the production of sodium salts in the United States dur[illegible] was [illegible] by the most important [illegible] and it is believed that [illegible] for the year [illegible] considerable tonnage to hold as stock. The [illegible] was maintained at about the same figure as in [illegible] tons, [illegible] for the year [illegible] a slight decrease from those of the pre[illegible]

The changes during the year [illegible] in a number of the works producing so[illegible] [illegible] Michigan Alkali [illegible] New Jersey [illegible] [illegible] The Franklin [illegible] [illegible] The Penn[illegible] [illegible] [illegible] [

and bleaching powder to three times what it was at the beginning of 1902. The American Alkali Co. appears to be so deeply involved in financial difficulties that its future is problematical. The property is now in the hands of a receiver. An agreement has been made with the Consolidated Lake Superior Co., whereby a half interest in the Canadian Electro-Chemical Co., whose stock is owned by the American Alkali Co., is transferred to the former company in settlement of its claims. The Pennsylvania Salt Manufacturing Co. during the year 1902 has continued work on its electrolytic plant at Wyandotte, Mich. It was expected that this plant would be completed and in operation by the fall of 1902. This expectation has not been realized, however, and the plant is not yet producing caustic soda or bleaching powder. The Dow Chemical Co. is enlarging its plant at Midland, Mich., to double its present capacity, and in order to pay for these improvements, $115,000 new treasury stock has been issued.

The annual report of the Electrolytic Alkali Co., Ltd., operating the Hargreaves-Bird process, for the year ending Aug. 31, 1902, states that the net profit for the year was £6,420, to which must be added £1,242 brought forward from the previous fiscal year, making an available balance of £7,662, out of which a cumulative dividend of £7,331 is to be paid, leaving £331 to be carried forward. The United Alkali Co., Ltd., for the calendar year 1902 reports assets of £9,031,249, consisting of property, plant, etc., valued at £7,226,661; stocks of manufactured products, raw material, stores, etc., on hand, £738,488; debts owing to the Company, £261,611; outstanding consignments, £36,649; investments, £478,213; cash on hand and bills receivable, £289,627. The gross profits for the year were £434,028, and net profits, £242,796. The balance brought forward from the previous year was £38,107, making a total of £280,902 available for distribution, out of which a 7% dividend on the preferred stock amounting to £185,612 was paid, £15,000 transferred to debenture redemption account, and the balance, £80,290, brought forward.

IMPORTS OF SODA PRODUCTS INTO THE UNITED STATES.

	1898.		1899.		1900.		1901.		1902.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
		$		$		$		$		$
Soda, nitrate..	330,386,560	2,298,240	328,142,080	3,486,313	407,921,920	4,935,520	467,384,960	5,997,595	661,348,800	5,995,375
Soda, bicarb...	280,988	5,794	162,398	5,219	133,137	4,509	(b)	(b)	176,480	6,485
Soda, caustic..	24,981,873	354,270	13,363,529	186,008	8,403,749	150,530	3,812,847	94,303	3,334,697	77,492
Soda ash (a)...	73,064,707	447,119	57,053,837	425,205	73,815,425	613,379	31,415,788	276,261	31,899,092	284,634
Oth'r soda salts	23,354,295	256,958	26,340,840	355,502	20,351,801	255,298	14,491,559	189,543	16,973,762	277,363
Lime, chloride.	108,462,828	1,229,978	123,582,061	1,203,364	132,510,478	1,534,205	120,611,346	1,673,190	112,374,478	1,456,435

(a) Including sal soda. (b) Included in other soda salts.

Market Conditions.—The average monthly price of domestic 58% ash per 100 lb. in lots of 50 tons or more f. o. b. works, is given in the following table:—

Year.	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ave
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts
1898.....	53·75	51·25	53·75	50·50	57·50	57·50	51·50	52·50	50·00	59·00	57·50	57·50	5
1899.....	57·50	59·20	62·50	66·50	67·50	63·75	68·75	70·00	71·75	80·00	82·50	82·50	6
1900.....	86·66	87·50	87·50	82·50	82·50	82·50	82·50	82·50	77·50	77·50	72·50	75·50	8
1901.....	80·00	80·00	74·00	80·00	78·75	77·50	80·00	76·50	75·50	77·50	78·50	85·00	7
1902.....	84·08	80·75	80·50	82·50	82·50	82·50	82·50	83·50	85·00	85·00	84·50	88·13	8

depth of from 5 to 45 ft., but no water has been found, the nearest point at which water can be obtained is Furnace Creek, 35 miles distant. The deposit is also a considerable distance from railroad communication, the nearest line being at Johannesburg, 125 miles from the beds. The deposit is to be worked by the American Nitre Co. which was organized in 1901, and which has established a laboratory at Camp Inyo, Inyo County, Cal.

Chile.—The report of the Asociación Salitrera de Propaganda (Nitrate Propaganda Association) states that the production of sodium nitrate in 1902 amounted to 29,829,679 quintals (1 quintal=101·61 lb.), an increase of 1,461,319 quintals over the production in 1901. The exports were 30,089,440 quintals as compared with 27,385,228 quintals in the preceding year. The total deliveries in 1902 amounted to 28,400,840 quintals, being 2,937,032 quintals less than in the previous year. The decrease was due to a decreased consumption in Europe and other countries of 3,339,998 quintals, offset by an increase in the consumption by the United States and Chile of 402,966 quintals. The visible supplies on Dec. 31, 1902, amounted to 21,966,244 quintals, distributed as follows: For Europe, on shore, 5,599,440 quintals; afloat, 9,427,470 quintals; total, 15,026,910 quintals; for the United States, on shore, 166,634 quintals; afloat, 1,288,700 quintals; total, 1,455,334 quintals; the stock on the coast of Chile amounted to 5,484,000 quintals. In December, 1902, there were 78 nitrate works in operation. Of the companies engaged in this industry the Alvanza Co. showed the greatest net profits in 1902, £174,907, and paid a dividend of 10%; the Rosario Co. showed a net profit of £140,104, and paid an 8% dividend. The greatest dividend payers were the Santiago and Liverpool Co.'s, the former paid 18% and the latter 17·5%. In order to keep within the limits of the output fixed by the combination for 1903, and to allow for new producers coming into the combination, which now consists of 16 companies, the individual quotas of present producers will have to be reduced about 25%. The Salar del Carmen Nitrate Syndicate reports for the year 1902 gross profits of £54,754, and net profits of £44,289, out of which a dividend of £10,950 (10%) was paid, leaving a balance of £1,135 to be carried forward.

On March 16, 1903, the President of the Republic was authorized to sell at public auction for the term of one year, 24 nitrate properties, 16 being in Tarapacá and 8 being at Toco.

The following table was obtained from the report of W. Montgomery & Co., London, the figures being for the 12 months ending June 30:—

	1899.	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.
Shipments from South American ports to all parts	1,373,000	1,351,000	1,452,000	1,278,000	1,329,000
Consumption in United Kingdom	121,000	126,000	126,000	111,000	112,000
Consumption on the Continent	981,000	1,026,000	1,042,000	897,000	1,003,000
Consumption in the United States	133,000	170,000	200,000	190,000	240,000
Consumption in other Countries	25,000	28,000	14,000	16,000	19,000
Consumption in the world	1,260,000	1,350,000	1,382,000	1,214,000	1,374,000
Visible supply on June 30	326,000	298,000	332,000	353,000	270,000

It has been declared by the committee of the producers that not more than *31,750,000* quintals shall be shipped during 1903, but as the committee has th

reason the figures, it is probable that the quantity finally declared will not quotable.

Conditions.—At the opening of the year 1902, sodium nitrate was New York at $1 95@$1 975 per 100 lb. Prices began to rise and in was quoted at $2 10@$2 35, and in March at $2 30@$2 40. This was reported to be due to delayed shipments and a strike at Iquique Bureau, Chile. At the beginning of April, sodium nitrate was still $2 25@$2 40, but from the end of April to July, prices declined 10c. lb. Between July and October, prices fell from $2 05 to $1 85, rose to $1 95@$2 025, and in December to $2 10@$2 25, but closed The quotations for future deliveries were more steady, the year opening quoted at $1 95@$1 975 per 100 lb., in February and March $2 10, but fell to $1 925@$1 975 in May, to $1 825@$1 85 in July, at these figures till the end of the year.

Sodium. Although there are several works in the United States using metallic sodium, statistics of their production are not available. entitled the Manufacture and Uses of Metallic Sodium, appeared in of the *Franklin Institute* January, 1902, pp. 65-74, in which Mr. ng described his process and the sodium plant of Harrison Bros. & Co., phia, Pa.

STONE.

THE leading varieties of stone produced in the United States in the order of their importance are limestone, granite, sandstone, marble and slate. Detailed information as to the important quarrying centers, character of their output and the relative value of stones for different uses, will be found in THE MINERAL INDUSTRY, Vol. VIII.

The total value of the stone produced in the United States during 1901 amounted to $55,488,137, against $45,066,708 in 1900; neither of which total includes the sandstone used in the manufacture of grindstones and whetstones which is included under silica, and are also exclusive of the value of the production of slate. The statistics covering the year 1902 are not yet available.

Limestone.—The value of the total production during 1901 was $26,406,899, the value of that used for building being $5,219,310, including $404,163 for railroad bridges; for railroad ballast, $1,758,541; for macadam, $2,298,286; for concrete, $1,214,815; for riprap and rubble, $1,024,109; for the production of lime, $8,204,054; for blast furnace flux, $4,659,836, and for the limestone used in the manufacture of Portland cement, $570,882. The principal producers rank in the order of maximum production as: Pennsylvania, with a production valued at $5,081,387 for 1901; Illinois, $2,793,837; Indiana, $2,993,186; Ohio, $2,606,502; New York, $1,738,716; Missouri, $1,362,272; Wisconsin, $1,225,448.

Granite.—The total value of the granite produced during 1901 amounted to $15,976,971, which includes that used for concrete, $477,709; for road making, $2,008,966; and for railroad ballast, $516,768; for curbing and flagging, $670,703; riprap and rubble, $1,755,959; sold in the rough, $3,486,574; for paving blocks, $1,821,431; and for dressed building stone sold by the producers, $3,781,294. The principal States rank in the order of their maximum production as: Maine, $2,703,116; Massachusetts, $2,216,258; Vermont, $1,245,828; California, $1,134,675; South Carolina, $996,084 and New Hampshire, $935,494.

Sandstone.—The total value of the production during 1901 was $8,844,978, of which was used for building purposes, $4,875,973; for railroad ballast, $30,887; for road making, $130,503; for concrete, $123,957; for paving, $358,910; for riprap and rubble, $447,520; for curbing, $636,722; for flagstones, $1,026,499; for other purposes, including grind and whetstones, $1,214,007. The principal producing States rank in the order of production as: Ohio, with a total production valued at $2,576,723; Pennsylvania, $2,063,082; and New York, $1,331,327.

Marble.—The total value of the marble produced during 1901 was $4,965,699, of which that used for building purposes was $1,236,023; for ornamental work, $126,576; sold in the rough, $591,667; for interior work, $1,008,482, and for cemetery work, $1,948, 892.

The Testing of Building Stone[1]

By Edwin C. Eckel

Absorption.—Changes of temperature, as already indicated may of themselves cause serious injury to a stone; but when taken in connection with the action of water contained in the pores of the stone, the effect is greatly augmented. The tests applied for expansion are mainly to determine the effect of alternate heating and cooling, and particularly of high heating and rapid cooling. The tests for porosity or absorption, on the other hand, are carried out with a view to determining the probable resistance of the stone to the action of frost. Other things being equal, it is obvious that the stone which absorbs the greatest quantity of water per cu. in. in a given time, will be the stone that is subject to the greatest injury at low temperature owing to the freezing of the water contained in it.

The action of frost is frequently simulated by using in the absorption test, instead of pure water, a saturated solution of some salt, which expanding on solidifying, tends to crack or disintegrate the stone. Tests of this type have, however, fallen largely into disuse.

Chemical Tests.—In regard to uniformity in analytical methods marked progress has been made during the past few years. Dr. Hillebrand has described[2] in great detail the methods of rock analysis followed in the laboratory of the United States Geological Survey, and it seems probable that future progress in the standardization of such methods will follow closely along the lines of his paper. The practical value of a chemical analysis depends largely on the type of rock in question. In the case of a granite, trap, or other crystalline igneous rock, an analysis is of itself of little service, though it may do some good if taken in connection with a careful microscopical investigation. With sandstones, analyses are somewhat more useful, in determining the character of the cementing material, though even here a microscopical investigation will probably be more serviceable. The value of a chemical analysis is greater in the case of limestones and slates, particularly the latter.

Microscopic Examination.—The examination, under the microscope, of thin sections of a stone serves to determine the characters and condition of the component minerals, the shape and method of aggregation of the individual grains; and, in the case of non-igneous rocks, the character of the cementing material. Microscopic examination, therefore, is perhaps the most valuable single test; but it is the one which can least readily be applied by the quarryman or engineer, as instruments and training are rarely obtainable.

Field Examination.—The examination of old buildings, and of natural exposures of the stone under test are valuable aids to a determination of its probable durability. Field examination requires, however, a good knowledge of the geological history of the area in which the quarry occurs, as the degree to which a natural exposure of the stone has disintegrated will depend not only on the character of the stone, but on the length of time it has been exposed to the weather. Rock areas in New York and New England are rarely weathered deeply, as this district was swept clean during the Glacial period, while rocks of similar type in the Southern States may be covered by from 50 to 150 ft. of material resulting from their own disintegration.

[2] W. F. Hillebrand Bulletin, 176, United States Geological Survey.

SULPHUR AND PYRITE

WORLD'S PRODUCTION OF SULPHUR. (*a*) (IN METRIC TONS.)

Year.	Austria (*d*)	France. (*c*)	Hungary	Germany	Greece.	Italy. (*b*)	Japan.	Russia.	Spain. (*f*)	Sweden	United States.
1897.....	530	10,723	112	2,317	358	496,658	12,013	574	*b* 3,500	*Nil.*	1,717
1898.....	496	9,818	93	1,954	135	502,351	10,339	1,018	3,100	50	2,779
1899.....	555	11,744	116	1 663	1,150	563,697	10,241	451	1,100	*Nil.*	1,388
1900.....	862	11,551	123	1,445	891	544,119	14,435	1,586	750	70	4,704
1901.....	4,911	7,000	137	963	3,212	568,096	(*e*)	(*e*)	610	*Nil.*	6,896

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to about 31,000 long tons in 1898 is not included. (*b*) Crude. (*c*) Raw mineral; limestone impregnated with sulphur. (*d*) Crude rock. (*e*) Statistics not yet published. (*f*) Production of crude rock was 58,922 metric tons in 1899; 64,364 in 1900 and 49,856 in 1901.

Nevada.—The Nevada Sulphur Co. operates at Rabbit Hole Springs, 35 miles from Humboldt, Humboldt County. The sulphur rock occurs in beds of considerable thickness and extent included between limestone and magnesian rocks, and are worked by means of tunnels. All rock containing over 8% S is mined, this being considered the minimum limit that repays extraction, but a large portion of the material averages very high. From the mines the rock is carried in cars to the refinery, which treats about 225 tons per month. Thirty men are employed. The sulphur is drawn by wagons to Humboldt for shipment. It is said to be of superior quality and finds a ready market on the Pacific Coast in spite of the competition of Japanese sulphur.

Utah.—The Utah sulphur deposits are situated in the vicinity of Gold Mountain and Marysvale. About 1·5 miles west of the deposits is an old crater, and the country northwest of it shows a recent flow of lava. The country south and west is porphyritic, but on the north is more basic. On the west bordering on the deposits are low hills of honeycombed gypsum from which building stone has been taken. It is possible that the sulphur owes its formation to volcanic action, but the presence of gypsum in the vicinity indicates that the beds have been formed in a manner similarly to those of Texas and Louisiana. The principal deposit from which most of the sulphur has been mined is located in Beaver County near the Millard County line; the outcrop extends for 7 or 8 miles north along which the Utah Sulphur Co. have 8 or 10 promising claims. The deposits were known to the early pioneers, who obtained small quantities of almost pure sulphur from the numerous caves. Soon after 1870 the deposits were located under the mining laws, and a small furnace installed. The plant was afterward enlarged and successfully operated until about 1885. In 1891 the Meyer Bros. Drug Co. of St. Louis bought control of the property, and the smelter was rebuilt, and a new mill for grinding the sulphur installed. Since then the mines have been worked continuously with success. The smelter is not usually operated during the winter season, as the mines are worked by open cutting. The smelter has six stacks or retorts; four of which are generally operated at one time, handling 50 tons of 20% rock per day. The capacity of the mill is from 15 to 18 tons of sulphur in 10 hours. The refinery will yield about 2,000 lb. of flower sulphur and 1,000 lb. of pure rock sulphur per day. The rock sulphur is used for making roll sulphur or is ground and sold as flour sulphur.

Chile.—The native sulphur mines near Arica were actively worked during 1901 as well as the deposits at Taltal; the total output of the country being consumed by the nitrate works in Tarapaca and Atacama for the manufacture of

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1893-1900. (a) (IN LONG TONS

Country.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902
Austria	11,494	12,170	13,799	15,993	15,796	18,519	21,594	18,842	19,0
Belgium	5,644	6,410	7,527	9,253	8,402	7,481	9,721	7,471	12,3
France	56,932	69,696	76,739	84,895	88,657	96,043	103,647	74,394	67,8
Germany	16,437	15,472	15,680	19,721	27,048	25,923	28,702	23,448	25,9
Greece and Turkey	16,870	16,195	18,556	13,866	24,808	18,656	19,647	21,702	20,4
Holland	2,365	3,335	3,834	3,599	5,646	6,408	18,595	10,848	8,0
Italy	49,895	49,349	54,009	73,052	62,652	87,230	101,073	74,516	45,8
Portugal	8,670	14,562	12,001	7,054	8,257	12,269	10,937	11,335	12,1
Spain	3,445	5,753	5,910	4,039	3,233	7,757	6,187	2,979	.....
Sweden and Norway	b7,887	b5,780	b14,540	b11,226	b12,331	b12,476	b22,681	b24,486	b24,5
Russia	17,977	17,962	18,752	17,532	12,285	19,211	22,090	15,110	17,5
United Kingdom	22,165	24,043	21,913	24,520	26,983	25,038	23,973	22,464	25,(
United States	105,773	99,227	124,923	118,137	138,435	128,441	162,505	144,817	168,(
Other countries	3,376	7,732	8,562	7,651	12,791	13,569	6,810	9,887	13,(
Totals	328,930	347,636	396,745	410,538	447,324	479,031	558,162	462,299	467,(
Stock in Sicily at end of year	198,513	203,756	222,999	240,367	248,023	277,098	221,204	302,410	334,(

(a) From report of A. S. Malcomson, New York. (b) Includes exports to Denmark.

dividend for the balance of the year (£18,430 less income tax) was propo making a total distribution in preference shares of £35,597. Of the bala £10,736, or 20%, has been credited to the capital guarantee fund which amounts to £64,626. An additional sum of £20,499 has been added to the res for depreciation of stock, increasing it to £57,029. The general reserve fun £121,982.

Japan.—The production of sulphur in Japan during 1901 amounted to 16, tons, valued at $192,229, as compared with 14,435 metric tons, valued at $165, in 1900. The output during 1902 was derived mainly from the provinces Hokkaido, Rikuzen, Asumi and Shenaro. In recent years a considerable qu tity of Japanese sulphur has been imported into the United States amount during 1901 to 10,705 long tons, valued at $206,899.

Mexico.—Apart from the immense quantity of native sulphur contained the crater of Popocatepetl (negotiations for the purchase of which from Mexican Government by Standard Oil interests have been reported), there very large deposits of native sulphur in the states of Chiapas, Durango, San L Potosi and Zacatecas, which have not been exploited except to a very limited tent. At Mapimi and Cerritos in Durango, a very large output could be m tained for years to come. The total consumption of sulphur in Mexico is e mated at 1,000 metric tons, of which about one-half is imported. A sulphur m in Zacatecas on the Mexican Central Railroad is reported to have been sold $100,000 gold to a New York dealer.

Peru.—Sulphur is found in sedimentary deposits in the Department of Pi and although it occurs in large quantities on all of the volcanoes of the An but little is produced—the output for 1900 being 634 kg.

Russia.—The production of sulphur in Russia during 1900 was 1,587 me tons, as compared with 1,018 tons in 1899. The output for 1900 was obtai from Daghestan, Poland and Turkestan.

Spain.—In addition to the sulphur contained in cupreous iron pyrite, th are mines of native sulphur in the provinces of Albacete and Murcia from wh *49,856* metric tons of crude sulphur ore, valued at 296,561 pesetas, were obtai *during 1901*, as compared with 64,364 tons valued at 549,733 pesetas in 19

PYRITE

treated by the Henderson process, have been sold either in the form of "fines," or after briquetting, for the manufacture of steel direct, but, so far, roasted pyrite residues have not been so utilized in the United States on account of the large percentage of sulphur remaining in them after treatment in the chemical works. The utilization of pyrite residues for the manufacture of pig iron would result in the saving of several hundred thousand tons of iron annually, from what is now a waste product.

The Canadian mines at Capelton have made no increase in the shipment of pyrite to the United States and the sulphur in these ores continues to be consumed by Boston chemical works and the Nichols chemical works of New York.

In Newfoundland an American company capitalized at $500,000 is operating the deposit of pyrite on Pilley's Island adjacent to the old Pilley's Island mine, through the workings of which the ore is removed. Several thousand tons of pyrite were shipped to New York during 1902, and early in 1903 a quantity of pyrite was shipped to the works of the Dominion Iron & Steel Co. at Cape Breton, N. S., for the manufacture of sulphuric acid used to collect the ammonia from the producer gases by washing them before they enter the open-hearth furnaces.

Imports and Exports.—In addition to the large increase in the production of pyrite in the United States during 1901 and 1902, there was a very large increase in the quality of pyrite imported, the statistics of imports for 1902 and 1901 being, respectively, 440,363 long tons ($1,650,852), and 403,706 long tons ($1,415,149). Since 1891 the quantity of pyrite annually imported has exceeded the annual domestic production. The exports of pyrite from the United States during 1902 were 3,060 long tons, valued at $19,860, as compared with *nil* in 1901.

Market.—The purchase of all domestic and foreign pyrite and other ores used for the sulphur content in the United States continues practically in the hands of four trade combinations, and, as the total purchases of the ores amount annually to about 500,000 tons, stocks of foreign ores can be accumulated at the seaboard and shipped inland in quantities to secure lowest freight rates. These conditions favor the importation of foreign ores and leave but little incentive to develop domestic mines of uncertain character. Notwithstanding the large increases in both the production and the imports of pyrite in 1901, the price of the domestic product advanced from $3·67 per ton in 1900 to $4·36 per ton in 1901, although it declined to $4·28 in 1902. In a similar manner the value of pyrite imported increased from $3·27 per ton in 1900 to $3·51 per ton in 1901 and to $3·74 in 1902.

Pyrite Mining in the United States during 1902.

Massachusetts.—The mine of the Davis Sulphur Co. in Franklin County was the only producer during 1902; the output being practically the same as that of 1901.

New York.—(By W. H. Adams.)—The production of pyrite during 1902 was considerably less than that of 1901, owing to the continued idleness of the Stella mines at De Kalb Junction. The High Falls Pyrites Co., in St. Lawrence

the United States using pyrite in place of sulphur in the treatment of wood p... although in Europe a considerable quantity of pyrite is utilized for this purp... Another important factor in the industry has been the increased production ... phosphate rock from Florida and Tennessee and the domestic manufacture ... superphosphates; for which purpose a chemically pure sulphuric acid is not ess... tial, that made from pyrite serving the purpose equally as well as that made fro... sulphur.

Assuming that the stocks carried forward from one year to another are pra... tically the same, and estimating the domestic consumption by combining the im... ports and the domestic production, it will be seen that the quantity of iron pyrite... consumed in this country in 1902 was 668,561 long tons, as compared with 638,531 long tons in 1901, and 527,099 long tons in 1900.

WORLD'S PRODUCTION OF PYRITES. (*a*) (IN METRIC TONS.)

Year.	Belgium.	Bosnia.	Canada.	France.	Germany.	Hungary.	Italy.	Newfoundland.
1897.....	1,928	3,670	35,299	308,448	133,302	44,454	58,350	3,...
1898.....	147	240	29,228	310,972	136,840	58,079	67,191	3,...
1899.....	283	430	25,117	318,832	144,633	79,519	76,588	3,...
1900.....	400	1,700	36,316	305,073	169,447	87,070	71,616	3,...
1901.....	.....	4,570	32,311	307,447	157,433	98,907	89,256	7,...

Year.	Norway.	Portugal. (c)	Russia.	Spain. (d)	Sweden.	United Kingdom.	United States.	Totals.
1897.....	94,484	210,955	19,380	217,545	517	10,753	128,468	1,...
1898.....	89,763	248,218	24,570	269,016	386	12,302	194,219	1,...
1899.....	95,636	275,658	23,251	319,285	150	12,496	191,263	1,...
1900.....	98,945	345,339	(*b*) 25,000	356,018	179	12,484	204,536	1,...
1901.....	101,894	215	.....	(*e*) 393,397	*Nil.*	10,405	(*e*) 290,973	.....

(*a*) From the official reports of the respective governments except the figures for Spain in 1897, which are taken from C. Le Neve Foster's report. (*b*) Estimated. (*c*) Under Portugal is included only the output of pyrites carrying less than one per cent. of copper. Considerable amounts of the richer sulphides are also used in sulphuric acid manufacture. (*d*) Does not include the production of copper-iron pyrites, from which the copper is extracted in Spain. (*e*) Long tons.

Sulphuric Acid.—The average prices of chamber and concentrated sulphuric acids in 1901 and 1902 are given in the subjoined table, which has been compiled from the *Engineering and Mining Journal:*—

Month.	Conc. Acid. 66° B. per 100 Lb.		Chamber Acid. 50° B. per Ton.		Month.	Conc. Acid. 66° B. per 100 Lb.		Chamber Acid. 50° B. per Ton.	
	1901.	1902.	1901.	1902.		1901.	1902.	1901.	1902.
January.....	$1·20	$1·20	$14·00	$15·00	July.....	$1·20	$1·20	$14·00	$14·50
February.....	1·20	1·20	14·00	15·00	August.....	1·28	1·20	14·00	14·50
March.....	1·20	1·20	14·00	15·00	September...	1·12½	1·20	14·00	14·50
April.....	1·20	1·20	14·00	15·00	October.....	1·10	1·20	14·00	14·50
May.....	1·20	1·20	14·00	14·60	November....	1·20	1·20	14·50	14·50
June.....	1·20	1·20	14·00	14·50	December....	1·20	1·20	14·50	14·50
					Average...	$1·17½	$1·20	$14·08½	$14·67½

PROGRESS IN THE SULPHURIC ACID INDUSTRY IN THE UNITED STATES DURING 1902.

BY FREDERICK J. FALDING.

SINCE the year 1900, the manufacture of sulphuric acid has been improved by the introduction, and the establishment upon a firm commercial basis, of the contact process. A more intelligent attention to structural details and a clearer

ployed. Surface condensers of several varieties, both air and water-cool commonly used between the lead chambers. The new furnace of the Macl type invented by A. O. O'Brien, of Richmond, Va., has been operated ve cessfully. This six-shelf furnace has a large capacity and possesses sever advantageous features. The construction of the Glover and Gay-Lussac has been much improved, especially as regards the care used in packing, proper proportioning of their capacity. Two Gay-Lussac tandem tow now in almost universal use. An output of 1 lb. of sulphur to from 10 to ft. of chamber space with a yield of from 95 to 97% of the theoretical q and a consumption of not over 3% of sodium nitrate in proportion to the s burned, while not universal is by no means uncommon.

The following table shows a partial list of sulphuric acid plants, built larged since January, 1900. This table, however, does not give any ac idea of the increase in manufacture of sulphuric acid, as nearly every e plant has been enlarged or has made additions to its apparatus, in order to an increased output. Since the above was written, contracts have been m the erection of a 50-ton tangential plant in Kansas and of two 25-ton tan plants, the one in Philadelphia and the other at Moosic, Pa.

LIST OF SULPHURIC ACID PLANTS COMPLETED OR IN COURSE OF CONSTRU SINCE 1900.

Name and Locality.	Equipment.	Ch Cap Cu
Richmond Guano Co., Richmond, Va.	4 intermediate towers.	
E. Frank Coe & Co., Barren Island, N. Y.		
Southwest Chemical Co., Argentine, Kan.	15 Gilchrist columns and fan.	
Lazaretto Guano Co., Baltimore, Md.	9 Gilchrist columns and fans.	
Western Chemical Co., Denver, Colo.		
Meridian Fertilizer Co., Meridian, Miss.	Pratt system.	
Bussey & Sons, Columbus, S. C.	Pratt system.	
Greenville Fertilizer Co., Greenville, S. C.		
Virginia-Carolina Chemical Co., Memphis, Tenn.		
Anderson Fertilizer Co., Anderson, S. C.		
Georgia Chemical Works, Rome, Ga.		
Dominion Iron & Steel Co., Sydney, C. B.		
Philip Carey Manufacturing Co., Lackland, Ohio.		
E. Rauh Sons Fertilizer Co., Indianapolis, Ind.	2 Gilchrist columns.	
Jackson Fertilizer Co., Jackson, Miss.	3 Gilchrist columns.	
Scott Bros. Fertilizer Co., Elkton, Md.		
C. H. Dempwolf & Co., York, Pa.		
A. P. Brantley Sons Co., Blackshear, Ga.		
Virginia State Fertilizer Co., Lynchburg, Va.	4 intermediate towers.	
Grasselli Chemical Co., Birmingham, Ala.		
Jarecki Chemical Co., Cincinnati, Ohio.		
Detroit Chemical Co. of Detroit, Mich.	5 Gilchrist columns.	
Federal Chemical Co. of Nashville, Tenn.	13 Gilchrist columns.	
Southern States Fertilizer Co., Savannah, Ga.	Pratt system.	
Virginia-Carolina Chemical Co., Dothan, Ala.	Hoffman.	
Ohio Farmers' Fertilizer Co., Columbus, Ohio.		
Armour Fertilizer Co., Atlanta, Ga.		
Virginia Chemical Co., Savannah, Ga.	Hoffmann intensifier.	
Merrimac Chemical Co., Boston, Mass.		
Sayles-Bleacheries, Saylesville, R. I.		
Bowker Fertilizer Co., St. Bernard, Ohio.		
T. P. Shepard Co., Providence, R. I.		
Virginia-Carolina Chemical Co., Albany, Ga.		
Standard Chemical & Oil Co., Troy, Ala.		
F. S. Royster Guano Co., Columbus, S. C.	7 Gilchrist columns.	
Griffith & Boyd.	Meyer tangential.	
Virginia-Carolina Chemical Co., Greenville, S. C.		
Total cubic feet.		6.
Total cubic meters.		1.

TALC AND SOAPSTONE.

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TIN.

By D. H. Newland.

The development of the tin deposits of the United States received more than usual attention from the public during 1902, but as heretofore there were no mines engaged in active commercial operations. Some experimental work was done near Hill City and Bear Gulch in the Black Hills, resulting in the formation of two companies to exploit the deposits, and operations were resumed in the district of the Santa Ana Mountains in southern California. In the light of previous unsuccessful ventures in these fields, the future of the new companies does not appear encouraging. Prospecting was also carried on in the vicinity of King's Mountain, N. C., where the occurrence of cassiterite in pegmatite dikes and residual clays was noted several years ago. Recent developments, it is stated, have shown the ore to be widely distributed. The deposits of the Franklin Mountains near El Paso, Texas, have proved disappointing in that the veins die out near the surface. There is reason, however, for believing that the ore bodies have been thrown by local faults, in which case they might be located in depth by cross-cutting. The upper portions of the veins carry good values in tin ore.

Technology.—The recovery of tin from tin-plate scrap was continued during 1902 by the Vulcan Detinning Co. at its plants in Sewaren, N. J., and Streator, Ill., by the Ammonia Co., of Philadelphia, and the Johnston & Jennings Co., of Cleveland and Chicago. Several new companies have been formed to engage in the industry.

According to H. Mennicke, in *Zeitschrift fuer Elektrochemie,* VIII., xxi., 1902, there are nine works in Europe, chiefly in Germany, which use the stannate process for the recovery of tin from tin scrap. In this process sodium hydrate is electrolyzed into Na and OH, which react upon the tin forming soluble sodium stannate. The latter compound is then decomposed, thus: $Na_2SnO_3+2H_2=2NaOH+H_2O+Sn$. The electrolytic bath is originally made up to contain 10% of caustic soda and is used at about 70°C. The temperature and the percentage of free alkali have great influence on the result. The absorption of carbon dioxide from the air must be guarded against, inasmuch as it reduces the conductivity, extends the time required, and causes a precipitation of tin hydroxide, forming a coating on the scrap, which interferes with the solution of the tin. The absorption of carbon dioxide cannot be prevented completely, and as the carbonate increases in quantity the electrolyte must be regenerated. This is done by removing a portion of the solution daily, and treating it first with carbon dioxide to throw down the tin as hydrate, and then after filtration with calcium oxide to convert the sodium carbonate into caustic soda. About 10% of the tin recovered from the scrap is obtained from this process of regeneration of the electrolyte. Fresh scrap usually yields from 2 to 3·5% of tin. The electrolytic stripping is stopped when the scrap attains a brown color, at which stage about 0·2% Sn remains undissolved. The best precipitate is obtained when

is maintained at 70°C. At higher temperatures there is a tendency to separation of spongy tin, and the metal is more likely to remain under solution. When the tin is crystalline, coherent and free from lead it usually results in melting it, but it may conveniently be pressed into bars. Lead, iron, arsenic and antimony pass into solution and remain therefore an impure scrap always yields an impure product. Method 2.—At the plant of the Vulcan Detinning Co. the scrap is treated in solution and the tin electrolytically precipitated therefrom in a coherent spongy form. The remaining sheet iron containing some tin is melted and cast into various cast weights and other objects of a desirable feature. The National Lead Co. absorbs the total Vulcan Detinning Co. and the American Can Co., and refines the tin by liquation in reverberatory furnaces. This tin subsequently appears in the form of Babbitt metal after having proportionately mixed with copper, [illegible]

amount of the tin dross recovered from dross wastes as well as from old linings" (the by-product of the solder refineries) are combined with lead dross and smelted in reverberatory furnaces to form matte. The crude pigs containing iron, copper and sometimes zinc are then separately melted with lead coal dust in a reverberatory furnace at a lower than the melting point of the harder metals with the result that the latter accumulate as "skimmings" on the surface of the bath in the furnace to be interspersed with the charges of the [illegible] which the purified tin-lead alloy is tapped off intermittently into [illegible]. In some instances several charges [illegible]

[illegible]

[illegible]

[

of sickening is probably due to a series of complex reactions between salt cake and iron and antimony oxides, whereby first iron sulphate is formed, and then the antimony takes the place of the sulphur in the iron sulphate, forming in the end reaction an antimoniate of iron, which oxidizes at the moment of casting. The use of a proper amount of coal, a hot furnace and a reasonably clean furnace hearth will do much to alleviate this trouble.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1897.....	55,172,571	$7,415,033	1899.....	71,248,407	$16,746,107	1901.....	74,560,487	$19,094,761
1898.....	62,748,899	8,770,221	1900.....	69,999,502	19,456,586	1902.....	85,043,358	21,383,227

THE PRINCIPAL TIN SUPPLIES OF THE WORLD. (*a*) (IN LONG TONS.)

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
English production	6,648	4,887	4,453	4,648	4,013	4,268	4,125	3,950
Straits shipments to Europe and America	47,840	47,180	41,700	43,350	44,460	46,070	50,339	51,881
Australian shipments to Europe and America	4,992	4,320	3,466	2,420	3,337	3,178	3,276	3,206
Banka sales in Holland	6,221	6,735	8,900	9,038	9,066	11,820	14,978	
Sales of Singkep in Holland	644	839	800	*Nil.*	*Nil.*	*Nil.*	*Nil.*	18,765
Billiton sales in Java and Holland	4,539	5,040	5,100	5,342	5,057	5,820	4,387	
Bolivian arrivals on Continent	.....	210	1,208	1,000	813	1,900		
Bolivian arrivals in England	4,097	3,829	4,208	3,464	3,940	5,037	9,670	10,150
Straits shipments to India and China	4,674	6,118	3,214	2,551	1,484	1,785	2,650	1,925
Totals in long tons	79,655	79,108	73,139	71,763	72,557	79,878	89,425	89,827
Totals in metric tons	80,930	80,374	74,309	72,911	73,718	81,156	90,856	91,284

(*a*) This table is based on the statistics compiled by William Sargant & Co., and Ricard & Freiwald, but the figures of English production are taken from the British blue-book. This table does not include the production of Germany, Austria, Spain, Portugal, and various other countries.

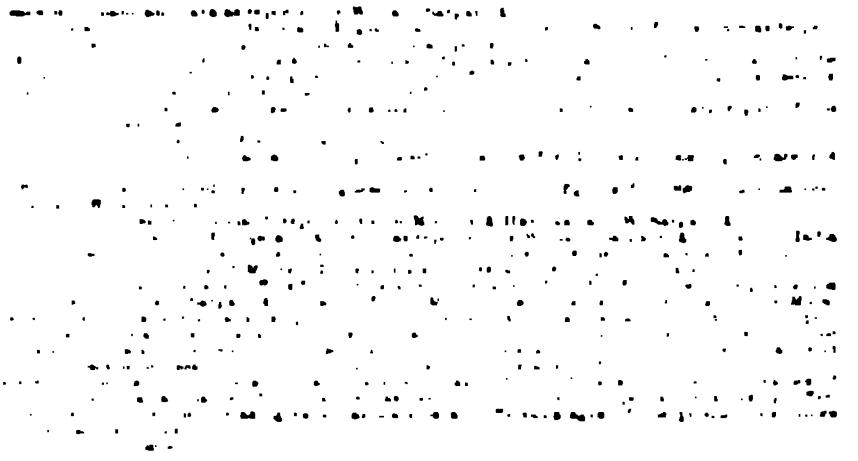
PRODUCTION OF TIN IN THE WORLD. (*n*)

Year	Australia. (*a*)			Austria. (*b*)			Banka and Billiton. (*c*)	Bolivia. (*d*)	England. (*e*)			Germany. (*f*)		
	Met. Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.	Metric Tons.	Metric Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.
1897..	1,150	$350,640	$303	48	$16,806	$350	14,224	5,594	4,524	$1,456,680	$322	929	$287,829	$310
1898..	908	302,825	333	48	19,074	397	14,610	4,535	4,722	1,729,060	366	993	372,252	375
1899..	835	490,690	587	41	24,639	601	14,496	8,012	4,077	2,540,470	623	1,481	870,730	590
1900..	915	600,160	656	40	27,651	691	18,234	10,245	4,336	2,939,345	678	2, 31	1,332,750	651
1901..	677	384,255	568	49	30,264	618	19,365	14,932	4,634	2,782,855	601	1,451	849,000	585

Year.	Japan. (*g*)	Mexico. (*h*)	Portugal. (*i*)	Russia. (*j*)			Singkep. (*k*)	Straits Settlements. (*l*)	Tasmania. (*m*)			Total Met. Tons.
	Met. Tons	Met. Tons.	Met. Tons.	Met. Tons.	Value (*o*)	Per M Ton.	Met. Tons.	Met. Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	
1897.....	47	1	1	2	$476	$238	813	45,632	3,484	$749,970	$308	75,479
1898.....	43	*Nil.*	*Nil.*	*Nil.*	.....	.....	685	46,635	2,088	705,810	346	75,211
1899.....	18	*Nil.*	*Nil.*	*Nil.*	.....	.....	678	46,679	2,275	1,355,433	596	78,592
1900.....	12	*Nil.*	*Nil.*	4	(*q*)	(*q*)	575	46,795	2,061	1,349,165	655	83,304
1901.....	(*p*)	*Nil.*	*Nil.*	(*p*)	(*p*)	(*p*)	793	51,339	1,818	1,062,710	584	95,058

(*a*) From *Report of Secretary of Mines and Agriculture of New South Wales*, which is the only Australian state that produces metallic tin. Tin ore is also exported from New South Wales. Tin ore is produced in Victoria, Queensland, South Australia, and Western Australia, but its metal contents are reported in the productions of other countries.

(*b*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.* The tin production of Austria is derived partly from domestic ores, and partly from Bolivian ores and impure tin from the East imported for refining.



CONSUMPTION OF TIN IN ENGLAND, AMERICA AND HOLLAND. (*a*) (IN LONG TONS.) (*b*)

	1895.	1896.	1897.	1898.	1899.	1900.
Consumption—						
Deliveries from London after deducting all shipments to America	17,222	19,015	17,118	15,472	13,519	16,82
Deliveries from Holland after deducting exports to London and America	9,029	10,150	11,680	12,130	13,084	14,48
English consumed at home	988	5,000	4,400	4,600	4,400	3,50
Exports of English, minus quantity shipped to America	5,530					
American consumption of all sorts	22,500	29,500	22,500	28,500	31,500	31,50
Billiton sent to other ports than Holland	1,532	1,603	1,370	2,120	1,980	2,40
Straits direct to Continent, less re-exports to America and England	7,622	11,400	9,170	12,740	6,470	5,40
Bolivian delivered from Liverpool	4,099	4,071	3,838	3,874	3,660	5,08
Bolivian delivered from Continent	.....	210	1,208	1,000	813	1,90
Totals	68,522	71,949	71,284	80,436	75,416	79,80

(*a*) From the annual metal circular of William Sargent & Sons. (*b*) Not classified for 1901 or 1902; the totals for these years are 87,700 and 93,982 tons respectively.

Bolivia.—(By J. B. Minchin.)—The tin deposits occur at intervals over a tract of country comprising the mountain ranges along the eastern edge of the great tableland, and extending some 300 miles from north to south with a width of about 20 miles. The more important deposits at present known are those of Huaina Potosi and Quimsa-Crur in the Department of La Paz; of Colqueri, Negro Pabellon, Morococala, Huanuni, Anteguera and Avicaya in the Department of Oruro; and Llallagua, Uncia, Potosi and Chorolque in the Department of Potosi. The lodes are inclined at angles of from 50° to 70°, and usually cut through highly inclined metamorphic shales, but occasionally they pass into the adjacent igneous rocks. They lie at altitudes varying from 13,000 to 15,000 ft. above sea-level, the mines at Chorolque and Quimsa-Crur even exceeding the latter limit. The width of the deposits varies greatly; every gradation is encountered from the narrowest veins up to lodes of 2 and 3 m. These lodes usually carry streaks of more or less pure tin ore, the rest of the lode matter being composed of compounds of silica and alumina, and of iron oxide with tin ore intermingled. In some cases the lodes are filled with soft clay carrying a large percentage of tin oxide in the form of grains and nodules, and occasionally rich pockets are found in which the whole lode is filled with nearly pure tin ore as a coarse sand. In these cases it is, of course, mined with great ease, but, as a general rule, the lode-matter is solid, and the country rock unusually hard.

The concentration mills are usually at altitudes of from 12,000 to 13,000 ft. above sea level, or from 1,000 to 2,000 ft. below the mines. Until recently the transport of ores to these mills was carried on exclusively by means of llamas and donkeys, and constituted one of the miners' chief difficulties, owing to the insufficient number of animals available, and the considerable cost, amounting to $1·25 per ton-mile. The Avicaya, Huanuni and Chorolque enterprises have lately put up ropeways for carrying their ores, which have a capacity of 8 tons per hour, and work by gravity, the cost of transport being reduced to about 12c. per ton-mile. The most important of the lines is that at Avicaya with an approximate length of 3 km.

No coal exists on the Bolivian plateau and the imported article from England, the United States or Australia, costs $30 per ton. Native fuel, "yareta," or llama

clearly established. Some of the principal lodes in Huanuni and Avicaya are still rich at from 300 to 400 m. below the outcrops. In other cases there appears to be a tendency for the value to fall off in depth, the tin ore being replaced by more or less poor iron pyrite.

Reliable statistics of Bolivian tin production are not readily obtainable. The approximate output of the principal enterprises may, however, be given as follows, in tons of black tin ("barrilla") per month: Huanuni Tin Mining Co., Huanuni, 65 tons; Teller Hermanos, Huanuni, 60 tons; other mines at Huanuni, 75 tons; J. Juleff, Antequera, 50 tons; Totoral Mining Co., 65 tons; Avicaya, 100 tons; Llallagua, 45 tons; Compañia Minera Uncia, Uncia, 35 tons; S. Patiño, Uncia, 80 tons; Chorolque, 90 tons; silver ore tailings, Oruro, 130 tons; total, 795 tons, equivalent to 525 tons metallic tin. To this total may be added a monthly production of 135 tons bar tin from the Potosi mines and 140 tons bar tin from all of the smaller workings, making the aggregate production of Bolivia about 800 tons bar tin per month, or about 9,600 tons per year.

Malay States.—The mining industry in the States of Perak, Selangor, Negri-Sembilan and Pahang is gradually passing into the control of large companies who work the deposits directly; consequently the number of small operators and tributers has shown a marked decrease in recent years. In 1901 there were 162,577 coolies employed in the mines as compared with 168,000 in 1900. The production in the individual States during these years was as follows:—

States.	1900.			1901.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
Perak	21,166	21,506	$13,714,365	22,980	23,266	$12,462,750
Selangor	16,041	16,298	10,393,655	18,010	18,299	9,792,985
Negri-Sembilan	4,900	4,979	2,786,155	4,478	4,550	2,434,910
Pahang	935	950	605,825	1,506	1,591	851,510
Total	42,442	43,123	$27,500,000	46,974	47,728	$25,542,105

The Pahang Corporation, Ltd., during the fiscal year ending June 30, 1902, earned a net profit of £22,240, out of which a dividend of 10% on the preferred stock was paid. The quantity of stone treated was 22,763 tons, yielding 622 tons of black tin valued at £48,501. The Kinta Tin Mines, Ltd., an English company which has secured a large property near Gopeng, Perak, began active operations in July, 1902, with eight monitors.

The tin industry of the Malay Peninsula has been described by Mr. Frank Owen in THE MINERAL INDUSTRY, Vol. IX. The following notes abstracted from an article by R. A. F. Penrose, Jr., appearing in the *Journal of Geology*, February-March, 1903, give some further details relative to the district of Kinta, Perak, one of the most productive fields of the Malay States.

The ore from the Kinta district is mined mostly from alluvial deposits, which vary considerably in character. In the larger valleys, the alluvium is commonly composed of sandy or gravelly clay, containing small quartz fragments together with pebbles and boulders of granite, gneiss, schist, limestone, etc. The alluvium in the hills, however, shows a greater variation in character in accordance with the different rocks from which it has been derived. It is frequently stained with iron and carries layers and masses of ferruginous material composed of granite

mine operated by the Leh Chin Tin Mining Co., it is found in the limestone a zone of fracturing sometimes as an impregnation, sometimes as lenses o regular pockets, and again along the cracks in the rock either longitudinal transversely with the zone of fracturing. It is associated here with large q tities of iron pyrites and arsenical pyrites, and smaller quantities of chalcop and bornite. At Bruseh in Perak, the ore has been found in seams and along the bedding planes of a soft, fine-grained sandstone, where it seems to been deposited by tin-bearing solutions which had leached through the older r

The methods of operating the mines are exceedingly crude, although in localities, such as Gopeng and Campar where English and French companie in operation, the work is carried on in a systematic manner. The smaller r are operated by Chinamen. The laborers are mostly coolies from southern C and Indians from the east coast of India. Native Malays do not take kind labor, and Europeans cannot stand hard work in this climate.

The tin-bearing alluvium is generally worked in open cuts or large pits where the overburden of barren ground is very heavy shafts are sunk. Th cavations when made by the Chinese are mostly shallow, owing to the diff of handling the water which is found in depth. On the average the pits ar more than 40 ft. deep. Some of the more progressive Chinamen have re introduced pumps to handle the water, and bucket pumps operated by a h tread-mill are commonly seen in this district. The tin alluvium after mined is carried to the surface in small baskets hung on both ends of a suspended on the carrier's back. The material is dumped into a wooden t supplied with a stream of running water, where, if there is much clay prese is stirred with shovels and hoes to separate the tin ore. The materials are ca by the water from the troughs into the sluices, where the ore and other h minerals sink to the bottom, and the lighter materials are carried away b stream. The sluices vary from a few feet to several hundred feet in length ac ing to conditions, and are made of wood or are cut in the sandy clay of the re After operations have been carried on for several hours, the flow of wat stopped, and the material at the bottom of the sluice is further concentrat panning in flat wooden bowls which resemble in shape the ordinary sheet gold pans. The final processes in the preparation of the ore consists in h picking the magnetite and other heavy minerals associated with the tin, w leaves a product varying from 69 to 73% Sn.

Hydraulic monitors for handling alluvium have been introduced at Gope the Gopeng Tin Mining Co.; and at Cacha an English company has erec stamp mill with concentrating tables to crush and concentrate the masses of At the latter locality, the alluvium has been indurated by infiltration of iron pou ads, so that crushing is necessary. The Sorakai Tin Mining Co. has er ro sting, crushing and concentrating machinery at Sorakai to treat the ore n in the granite at that locality. The roasting of this ore is made necessary b presence of arsenic.

The tin from the Kinta district was formerly smelted largely at local works most of it is now handled by the Straits Trading Co., which has a large sme

wood in the Cookstown district, and a large tin dressing plant is to be erected. Water is to be taken from the Finlayson River 7 miles away. The Stanthorpe district contributed 120 tons of tin ore from alluvial ground that could not be worked during seasons of average rainfall. The dredges built to operate in this district were idle during the entire year.

Tasmania.—The output of tin in 1902 was 1,958 long tons of metallic tin valued at £237,828 and 131 tons of ore valued at £5,162. During the fiscal year ending June 30, 1902, there were produced 2,807 long tons of ore valued at £198,127. The Mount Bischoff Tin Mining Co. in the last six months of the fiscal year crushed 50,044 tons of stone for a yield of 636 tons of concentrates. The cost of mining, crushing and dressing was 5s. 7d. per ton. The smelter treated 1,666 tons of concentrates, producing 1,176 tons of metal, of which 1,062 tons yielding 753 tons of tin were smelted on public account. The ingot tin assayed on the average 99·82% Sn. During the year the company earned profits of £62,612 and distributed dividends of £54,000. In the Blue Tier district the Anchor, Australian and Liberator mines were engaged in productive operations. The Anchor mine with its two 50-stamp batteries and complete dressing plant treated 48,174 tons of stone and obtained 167 tons of ore. With full water supply the mill could handle 100,000 tons of stone a year at an expense of about 2s. 6d. per ton; but the average number of stamps dropping in 1902 was only 34. A new water-race to the North George River, a distance of 27·5 miles, has been completed, and a further extension to the South George River will be constructed, which it is believed will afford an ample supply of water. The battery returns for the year showed an average extraction of 0·39%. At the Australian mine the milling facilities have proved inadequate to treat the stone, which averages less than 1% ore, on a profitable commercial scale, and many improvements have been undertaken to remedy this defect. The developments already made in the Blue Tier district show that there are immense quantities of low-grade material, the exploitation of which in the future will depend upon the supply of cheap water power. The Briseis mine on the Ringarooma River, owned by the Venture Corporation, has carried its scheme of water supply to completion, and is now provided with 40 miles of sluices that deliver a maximum of 2,088,000 gal. per hour. Mining operations so far have been restricted to removal of the overburden, which is being carried off at the rate of 10,000 cu. yd. a week. It is intended to continue this work until the tin-bearing drifts can be attacked on a large scale without fear of serious stoppage. A new electric plant is being installed for lighting and other purposes; while the method of elevating the material below sluicing-level by hydraulic pressure is to be adopted on a large scale. The quantity of tin stone secured from the overburden averages about 15 tons per month. At Bradshaw's Creek the Pioneer Tin Mining Co. earned a profit from the year's operations, obtaining 218 tons of stream tin from 227,900 cu. yd. of drift. At Branxholm the Arba Co. has made preparations for working on a more extended scale. In the Gladstone district the Scotia mine was the principal producer, furnishing 36 tons of ore out of a total of 77 tons. Operations at the Mount Rex mine were suspended for a part of the year, as some difficulty was experienced in finding a suitable market for the ore, which contains

[illegible] copper and lead. It is expected, however, that a successful [illegible] the Hermansa tin field has at [illegible] the discovery of a rich ore deposit at Mount [illegible] The property [illegible] Hermansa Mount Lyell Copper [illegible] but capital is needed [illegible]

[illegible] The Hermansa Mine Ltd. during the second half of 1902 [illegible] 111 tons of ore. The first half year [illegible] increasing the [illegible] per ton of [illegible] per ton to be [illegible] shaft [illegible] The state of [illegible]

| [illegible] | | |

Fair quantities of Bolivian tin are now being shipped, but sold at a discount, owing to inferior quality. Speculation again had full sway on both sides of the Atlantic, and prices showed wide fluctuations. Futures were selling at a discount practically throughout the year, which at times amounted to as much as 1c. per pound, and it was not until the latter part of December that the backwardation disappeared. The year opened rather dull, with spot tin selling at 22·75c., but as January progressed the market developed considerable strength, as high as 24·5c. being paid. Toward the end of the month a reaction set in, only to be followed by another upward movement, which assumed very large proportions. There was an exceedingly brisk demand, business in all lines being very satisfactory indeed, and prices advanced from month to month, culminating in a quotation of 30c. at the beginning of June. The lower cables from abroad and free offerings from the East caused quotations in July to decline, but spot tin remained scarce throughout the summer, all metal being forwarded direct from the steamers to the interior for consumption there. Bear sales in London and rumors regarding a strike at the mills of the American Tin Plate Co., which broke out later, caused a further drop during August, and in September as low as 25·375c. was accepted. Owing to a somewhat better demand prices advanced again during October to 26c., the demand being stimulated by a cut in the price of tin-plates and the settlement of the strike. Toward the end of November the decline in the silver market commenced to play havoc with tin, and continued to exercise a depressing influence for several weeks, consumers becoming afraid of the article and covering only their immediate wants. At one time the market ruled as low as 25c. At this figure, however, the trade evidently thought it safe to take hold of the article again, and large orders were placed for prompt as well as future delivery. The year closed with spot tin selling at 26·75c.; futures at about the same price.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1898	13·87	14·08	14·38	14·60	14·52	15·22	15·60	16·23	16·03	17·42	18·20	18·30	15·70
1899	22·48	24·20	23·82	24 98	25·76	25·85	29·63	31·53	32·74	31·99	28·51	25·88	25·12
1900	27·07	30·58	32·90	30·90	29·37	30·50	33·10	31·28	29·42	28·54	28·25	26·94	29·90
1901	26·51	26·68	26·03	25·93	27·12	28·60	27·85	26·78	25·31	26·62	26·67	24·38	26·54
1902	23·54	24·07	26·32	27·77	29·85	29·36	28·38	28·23	26·60	26·07	25·68	25·68	26·79

London.—The close of 1901 was marked by a general feeling of depression and weakness in this market; the gradual falling away from the high prices touched in the middle of the year, the expectation of increased production and the failure of a prominent dealer shortly before the New Year, all tending to cause a lack of confidence in the future of the article. This feeling found evidence in the backwardation in forward tin prevailing at the end of the year, and prices at end of December closed at about £106 for cash and £103 for three months. The visible supply of tin at the end of December amounted to 17,523 tons, showing a decrease for the month of 1,394 tons, but an increase of about 2,000 tons, compared with the end of 1900. In the first week of January prices declined gradually, and at *one time* touched £101 for spot and £98 15s. for three months. Toward the

TUNGSTEN.

THE production of tungsten ore in the United States during 1902 amounted to 250 short tons of concentrated ore, valued at $38,600 (which were derived from 3,730 short tons of crude ore), as compared with 179 short tons of concentrated ore, valued at $27,720, derived from 220 short tons of crude ore in 1901. The tungstic acid content of the ore produced in 1902 ranged from 50 to 65%, and the value of the high quality ore ranged from $100 to $300 per short ton, averaging $150. The production of tungsten metal in the United States during 1902 amounted to 82,000 lb., as compared with 13,000 lb. in 1901; ferrotungsten, 14,000 lb., as compared with 13,000 lb. in 1901, and tungstic acid and tungsten salts, 3,500 lb., as compared with 3,000 lb. in 1901. During 1902 there was no change in the prices for tungsten metal and ferrotungsten, the quotations remaining the same as in 1901, *i.e.*, from 58c. to 64c. per lb. for the former, and from 27c. to 31c. for the latter. The value of tungsten ore containing from 45 to 55% WO_3 is about $2 per unit, while ores containing from 55 to 65% WO_3 command from $2·50 to $4·50 per unit, if free from sulphur and phosphorus. The greater part of the output of tungsten metal and alloy during 1902 was derived from Colorado ores. Until recent years, the bulk of the supply of tungsten ores for consumption in the United States has been obtained from England; Austria-Hungary; Saxony, Germany and Australia. The chief use for tungsten is in the manufacture of tungsten steels and the growing demand for steels possessing the special property of self-hardening, has encouraged the exploration for tungsten minerals in the United States. A deposit of tungsten ore is being developed on the Ima Mining Co.'s property at Patterson Creek, a tributary of the Pahsimaori River, in Lemhi County, Idaho. The tungsten occurs as megabasite (manganese tungstate), and wolframite (iron tungstate), in brown and black crystals in a quartz gangue, the vein varying from 5 to 15 ft. in width, and assaying from 5 to 50% WO_3. Several other deposits are being exploited and much of the present importation of foreign ferrotungsten alloys may soon be replaced by metal and alloys made from domestic ores. This possibility is particularly pertinent, as tungsten minerals in some localities occur with gold and silver ores and tungsten metal may be produced from them cheaply as a by-product.

The chief use of tungsten is in the use of self-hardening tungsten steel, the metal being used either as ferrotungsten or as the powdered metal. Recently it has been added with very satisfactory results to a copper-aluminum alloy in order to impart greater strength and toughness. It is claimed that the self-hardening property of steel, ordinarily obtained by the addition of tungsten to chrome steel, may also be obtained by the addition of molybdenum, and in the latter case but one-half the quantity, as compared with tungsten, is needed to produce the same effect. The alloy known as tungsten-ferrochrome was imported into the United States during 1902 to the value of $7,046, as compared with $9,839 in 1901, Germany supplying the bulk of the import.

ZINC AND CADMIUM

United States Smelting Co. (formerly the American Zinc & Lead Co.) at Cañon City, Colo., manufactures a pigment called zinc-lead which is a mixture of oxidized compounds of lead and zinc. The production of this special pigment in 1902 was 4,000 short tons valued at $225,000 as compared with 2,500 tons valued at $150,000 in 1901.

PRODUCTION OF ZINC OXIDE IN THE UNITED STATES.

Year.	Quantity.		Value.		Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Ton.		Short Tons.	Metric Tons.	Totals.	Per Short Ton.
1897.....	26,262	23,825	$1,686,020	$64·20	1900.....	47,151	42,775	$3,772,080	$80·00
1898.....	32,747	29,708	2,226,796	68·00	1901.....	46,500	42,266	3,720,000	80·00
1899.....	39,663	35,982	3,331,692	84·00	1902.....	59,780	46,929	4,033,209	75·20

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES. (IN POUNDS.)

Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.	Oxide.	
					Dry.	In Oil.
1898.....	2,742,357	$109,624	$13,448	$123,072	3,342,235	27,050
1899.....	2,985,463	151,956	14,800	166,756	3,012,709	41,699
1900.....	2,013,196	97,762	36,836	134,598	2,618,908	38,706
1901.....	775,881	30,920	42,643	73,563	3,199,776	128,198
1902 (a).....	1,666,121	46,926	40,693	87,619	3,271,385	163,081

(a) In addition to the imports given in the above table there were imported during 1902, 1,247,936 lb. of white sulphide of zinc, valued at $32,879.

EXPORTS OF ZINC AND ZINC OXIDE FROM THE UNITED STATES. (IN POUNDS.)

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
1898.....	a 31,413,859	$552,064	20,998,413	$1,083,959	$138,165	$1,724,188
1899.....	b 67,126,506	1,002,542	13,509,316	742,521	148,232	1,978,295
1900.....	c 95,514,893	1,640,043	44,820,577	2,217,963	99,288	3,947,294
1901.....	d 97,434,283	1,560,943	6,780,221	288,906	82,046	1,931,895
1902.....	e 119,942,244	1,882,826	6,473,135	300,557	114,197	2,297,580

(a) Includes zinc oxide, 7,849,059 lb. ($252,194). (b) Zinc oxide, 10,685,226 lb. ($366,598). (c) Zinc oxide, 11,391,668 lb. ($496,380). (d) Zinc oxide, 9,122,283 lb. ($393,259.) (e) Zinc oxide, 10,716,364 lb. ($483,722).

Arkansas.—Some exploratory work was done in the northern part of the State, but the year's record on the whole, was disappointing. The deposits so far opened are of limited extent and have scarcely repaid the cost of development.

Colorado.—The ores of this State are rapidly becoming an important factor in the zinc industry. The Leadville district alone produced 85,699 tons of ore in 1902, and deposits were worked at Kokomo, Creede, Rico and elsewhere. The Kansas smelters took an increased quantity of these ores, which are purchased at a liberal discount from the Joplin prices and can be mixed in considerable proportions with the higher quality ores without materially affecting the smelting results. A large portion of the output is consumed by the United States Smelting Co., at Cañon City, Colo., for the manufacture of zinc-lead pigment, and some ore is marked at Mineral Point, Wis., and in Europe. The Colorado Zinc Co. at Denver and the Empire Zinc Co. at Cañon City have installed magnetic separating plants.

Kentucky.—Much activity was shown during 1902 in the zinc mining indus-

output of zinc ore assumed considerable proportions. The principal ... have been made in Cattaraugus County where there are deposits of ... sphalerite and blende with the limestone. The Old Jim mine near Marion ... in 1901 shipped several thousand tons of calamine to Mineral ... and Joplin, Mo. In the same locality are the Columbia, Tabb and ... mines. The last named mine produces smithsonite from a vein ... ft wide and is included between limestone and an altered ... The deposit is worked by an open cut some feet long from ... steel to the surface by a gasoline engine. Sphalerite is distrib... in small quantities and it is probable that it will replace ... below the water level, which occurs at a depth of about 150 ft. ... output is 30 tons of crude ore per day. The coarse lumps are hand ... sped without further treatment, but the fine material is run ... washer which is to be replaced in the near future by a jig. The ... and the presence of ... give it a very high assay ... Kansas. There was a further increase in the production of spel... as for several years past, the natural gas region of Kansas con... of the output. Outside of this district the only large smelting ... were those of the Bartlett Co. at St Louis, Mo. The principal ... smelters in Kansas are Iola, La Harpe, Cherryvale and Independence, the ... of great importance ... and sulphuric ... supplies. While there are ... in the Joplin district, all ... being purchased each ... considerable new and ... large ... were made from ... district. ... smelter ... for a large ... The ... ore shipped ... from ... have ... which, ... tax on the ... is ... prevent ... ing it can ... The new ore supplies from the West have relieved the ... extent from the danger of ... on the part of the ... would be hostile to the ... But ... ing in the Joplin ... are given in the separate ... by ... later in this section.

SHORT TON OF ZINC ORE AND LEAD ORE IN THE JOPLIN DISTRICT

ng.—The mines of the New Jersey Zinc Co. at Franklin Furnace, pro-

duced 209,386 tons of ore during 1902, an increase of 18,165 tons over the out... in 1901. The Trotter mine and the Stirling Hill mines were inactive. At t... Parker mine the work has consisted in extending the several levels in a southe... direction, while the open cut in the Taylor mine has been carried from the fo... down nearly to the tunnel level. The two mines are now in communication, a... that ventilation can be maintained throughout all the workings.

Virginia.—There were no new developments of importance during 1902, an... operations were limited, as heretofore, to the mines of the Bertha Mining Co... in Pulaski and Wythe counties, and the mine of the Wythe Lead & Zinc Co., a... Austinville. The capital stock of the latter company has been purchased by the... Bertha Mining Co., which will probably develop its properties on a large scale... The mill at the Clark mines, in Pulaski County, was run steadily, producing a... very satisfactory grade of ore. At the Bertha mines the work of stripping the... limonite ore was continued. There is an accumulation of from 30,000 to 40,000... tons of tailings from the old zinc mill containing about 18% Zn which it is... thought can be utilized.

PRODUCTION OF ZINC IN THE WORLD. (IN METRIC TONS.)

Year.	Austria. (a)	Belgium. (b) (f)	France (b)	Germany (b) (f)	Italy. (b)	Russia. (b)	Spain. (b)	United Kingdom. (c)		United States. (e)	Totals.
								Native Ores.	Foreign Ores.		
1898	7,302	119,671	37,155	154,867	250	5,664	6,081	8,711	19,676	108,514	[illegible]
1899	7,192	122,843	39,274	153,155	251	6,331	6,184	8,837	23,395	117,644	[illegible]
1900	6,742	119,317	36,305	155,799	547	5,963	5,611	9,214	21,098	111,794	[illegible]
1901	7,558	127,170	37,600	166,283	511	(d)	5,354	8,555	21,322	127,751	[illegible]
1902	7,960	(d)	(d)	174,927	500	(d)	(d)	40,244		602	.....

(a) The statistics for Austria are taken from the official reports of the Mines Department, except for 1902, for which the figure reported by Henry R. Merton & Co. has been used.
(b) Official statistics, except for 1902.
(c) The statistics for the United Kingdom are arrived at by deducting the zinc produced from domestic ores, as reported in the official Blue Books, from the total output of the smelting works as stated in the reports of Messrs. Henry R. Merton & Co.
(d) Statistics not yet available.
(e) Statistics compiled from direct returns by the producers to THE MINERAL INDUSTRY.
(f) According to Henry R. Merton & Co., Belgium, Holland and the Rhine district of Germany in 1902 produced 208,342 metric tons of spelter, against 202,474 metric tons in 1901, 189,301 in 1900 and 192,994 in 1899.

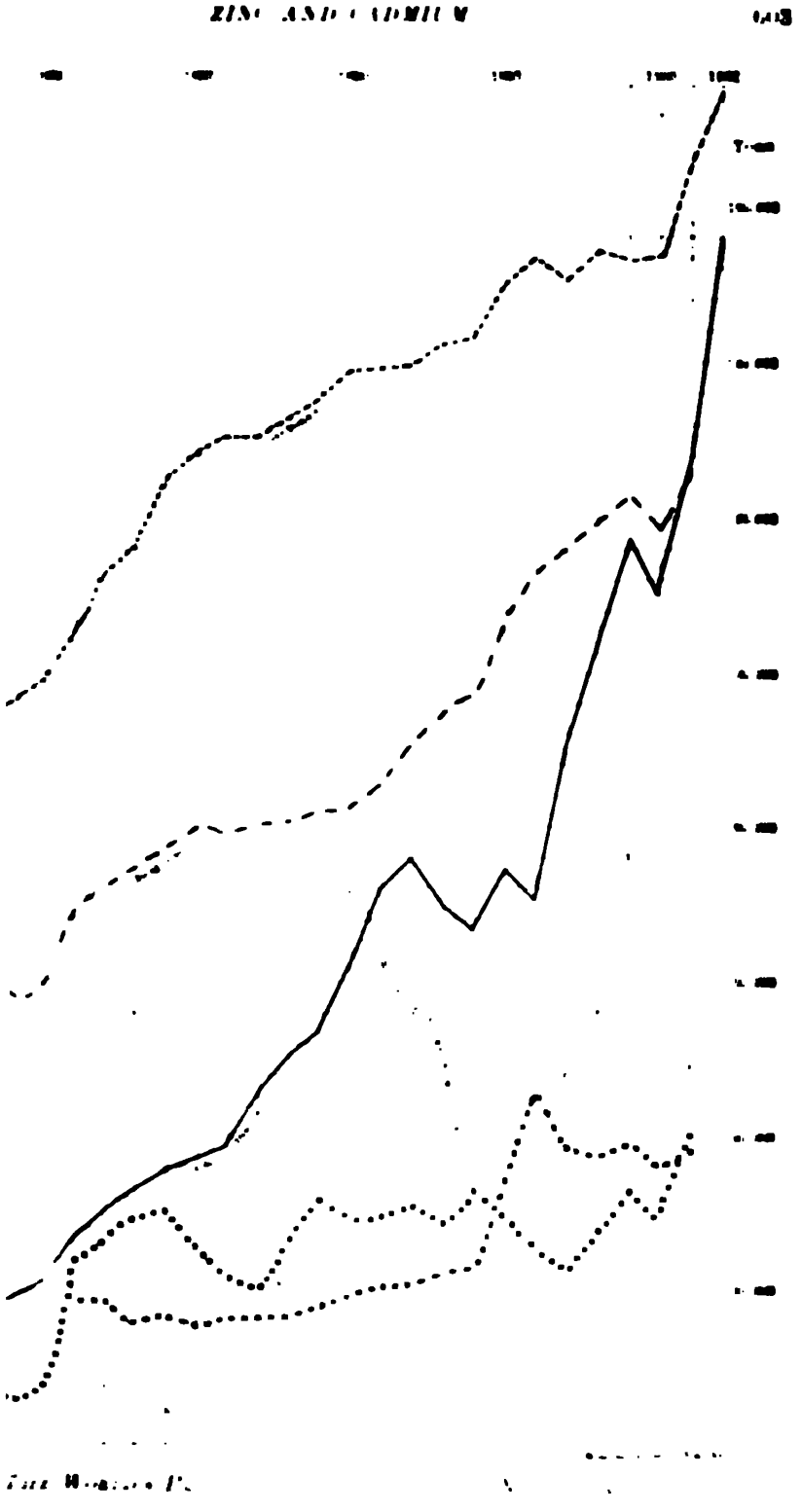
PRODUCTION OF ZINC ORE IN EUROPE AND AFRICA. (IN METRIC TONS.)

Year.	Algeria	Austria	Belgium.	France.	Germany.	Greece. (a)	Italy.	Norway.	Russia.	Spain.	Sweden	Tunis	United Kingdom
1897	32,260	27,463	10,954	83,044	668,850	30,906	122,214	908	54,534	73,848	56,636	11,830	19,567
1898	29,800	27,395	11,475	85,550	641,706	32,045	132,099	320	(b)	99,896	61,627	21,477	23,929
1899	42,970	37,100	(b)	84,813	664,536	22,907	150,629	379	(b)	119,710	65,159	20,079	23,505
1900	30,281	38,243	144,083	67,059	689,215	18,751	139,679	204	(b)	86,158	61,044	16,596	25,070
1901	26,913	36,072	(a)6,645	61,539	647,496	18,218	135,784	90	(b)	119,708	48,630	17,879	23,967

(a) Including blende and calcined calamine. (b) Not reported.

PRODUCTION OF ZINC AND CADMIUM IN FOREIGN COUNTRIES.

Algeria.—The output of zinc ore in 1901 amounted to 26,913 metric tons, valued at 1,312,660 fr., as compared with 30,281 metric tons, valued at 1,537,970 fr. in 1900. This production was obtained from the provinces of Constantine, Algiers and Oran. The entire production was exported, being shipped to Bel-



gium, France and Tunis. In the mines of Guerrouma, Sakamody, R'arbaa, Nador-Chaïr, the ore occurs as zinc blende in stratified marls, loam and calcareous formations. In the Constantine district the ore occurs as calamine in chalk gangue rock, the principal mines here being the Hammam, Sakiet Sidi Youssef, Compagnie Royale Asturienne, Compagnie Minière Tunissienne, Ban Kaf, Ban Jaber and D'jebel D'jedda. These mines together produce annually about 25,000 metric tons of zinc ore. In the Oran Department there are but two zinc mines, the Mazès and D'jebel Massen.

Australia.—The exports of zinc spelter and zinc concentrates from New South Wales in 1902 were 1,261 long tons, valued at £10,625, as compared with 632 long tons, valued at £4,057 in 1901. In the Broken Hill district the quantity of zinc in the lead and zinc concentrates was estimated at 29,432 long tons in 1902, but no value is placed upon the zinc content of the ore. Experiments are now being carried on with new methods for profitably treating zinc ores. The Sulphide Corporation, Ltd., has produced at its zinc distillation works at Cockle Creek a quantity of spelter from slimes.

Austria.—Zinc ore is mined in the provinces of Bohemia, Styria, Carinthia, Tyrol and Galicia. In Bohemia, the Mies, Mirklin and Wrbitz mines are operated by the Erste Böhmische Zinkhütten und Bergbau Gesellschaft; in Styria, mines at Deutsch Feistritz, Guggenbach, Rabenstein and Uebelbach are operated by the Märkisch-Westfälischer Bergwerk Verein; in Carinthia, at Raibl and Wolfsberg, and the mine of Bleiberg-Kreut, Windisch-Bleiberg Eisenkappel, Feistritz, and Meiss Schwarzenbach by the Bleiberger Bergwerke Union Actien Gesellschaft; and in the Tyrol, at Klausen, Schneeberg, Silberleiten, Nagelseekahr, Innst and Roncegno. The plants for smelting the zinc ore are at Cilli, Neidzieliska, Kiesz, Trzebinia and near Szczakowa. Practically all of the zinc ore exported is shipped to Germany, and nearly all the zinc ore imported is obtained from the same country.

Belgium.—The output of spelter from Belgium, Rhineland and Holland in 1902 was 200,140 long tons, as compared with 199,285 long tons in 1901. There are 12 zinc smelters, three of them owned by the Société Anonyme des Mines et Fonderies de Zinc de la Vieille-Montagne, which operates the Valentin-Cocq works at Hollogne aux Pierres, the Flone works at Hermalles-Huy and the Angleur works at Angleur, in Belgium, and at Bray-Ecos, Viviez, Dangu and Penchot, in France. This company owns mines in the departments of Gard, Herault and Lozère, in France, in the provinces of Santander, Almeria, Granada and Murcia, in Spain, and at Hammam and Ouarensis, in Algeria. Its output during 1902 amounted to 70,872 tons of spelter, 62,945 tons of sheet zinc, 8,642 tons of zinc oxide and 48,840 tons of sulphuric acid. The acid was manufactured at its plant at Baelen-Wezel. The gross receipts were 5,736,018 fr., general expenditures 1,210,686 fr., reserved for sinking fund, 815,067 fr., administration expenses 507,535 fr., interest 450,000 fr., dividends 2,700,000 fr., and the directors were paid 101,883 fr., leaving a balance on hand at the end of the year of 67,507 fr.

France.—In 1901 the production of zinc ore was 61,500 metric tons, which was obtained chiefly from the Malines mine in the Department of Gard, and the

122 metric tons ($14,676) of zinc oxide, and 66 metric tons ($10,586) of manufactured zinc. The imports during the same period amounted to 131 metric tons ($2,882) of zinc ore, 3,805 metric tons ($350,097) of spelter, 904 metric tons ($108,468) of zinc oxide, and 4,167 metric tons ($496,925) of manufactured zinc.

Spain.—The exports of zinc ore in 1902 amounted to 95,705 metric tons, compared with 75,755 metric tons in 1901. The district of Aguilas exported 366 tons; Almeria, 800 tons (£800) of calamine and 1,814 tons (£6,350) of calcined ore, all to Antwerp; Carthagena, 63,830 tons of zinc blende and 1,340 tons of calamine, mostly to Belgium, Mazarron 302 tons and Motril 233 tons (£622).

Sweden.—In 1902 there were 43,854 tons of zinc ore exported from Sweden, as compared with 41,251 tons in 1901. It is reported that zinc is being produced by an electric process from zinc-lead sulphide ores at the Onan plant of the Trollhattans Elektriska Aktiebolag, at Trollhattan. The new company, which is operating the process of Dr. De Laval, is capitalized at $26,800, and is obtaining zinc ore from the deposit at Saxberget, near Ludvika. A plant using Dr. De Laval's process has also been started at Hoslund, Norway.

United Kingdom.—In 1902 the output of zinc ore was 25,060 long tons, as compared with 23,752 long tons in 1901. Of the total in 1902, the Newcastle district produced 12,806 long tons and the Liverpool and North Wales district 7,566 long tons. The exports in 1902 were: 16,454 long tons (£54,216) of zinc ore, 6,650 long tons (£99,495) of spelter and 1,324 long tons (£37,563) of manufactured zinc; the imports during the same period being 44,598 long tons (£205,647) of zinc ore, 88,276 long tons (£1,528,962) of spelter, and 21,374 long tons (£489,554) of manufactured zinc. The English Crown Spelter Co., Ltd., produced 6,165 long tons, and Dillwyn & Co., 6,520 long tons of spelter during 1902.

THE SPELTER MARKETS IN 1902.

New York.—The year under review was fairly prosperous for the zinc industry of the United States, home consumers absorbing practically all the metal that was produced, in spite of a heavy production, and it was not until the very end of the year that stocks began to accumulate. Under these circumstances it was not necessary to export spelter in order to keep up domestic prices, as has been the case in former years. The higher prices of fuel and labor tended somewhat to raise the cost of production. Galvanizers, brass mills and sheet zinc manufacturers were very busy, and an increased quantity of spelter was again used for electrical purposes. The paint and oxide business also was satisfactory. One or two new smelting works were erected in the Iola Gas Belt, some of the older ones enlarged, and several smaller ones consolidated, thus creating a number of strong concerns. The result was an introduction of new business methods, which in the course of time will no doubt have beneficial results.

Larger quantities of ore are being shipped every year from Colorado and British Columbia—a plant having been built in Colorado to treat ores from the former locality—and it is evident to the intelligent observer that the newly found prosperity will come to an early end if new outlets cannot be found for an increased production. This fact has been recognized by the smelters, who have

tone, engendered by renewed inquiry from galvanizers, who were exceedingly busy, but toward the middle of the month, owing to sales of speculative parcels and second-hand metal, prices took a turn downward, and as low as £17 7s. 6d. was accepted, eventually rallying to £17 17s. 6d., which was about the opening price for April. A further active demand was experienced from makers of galvanized iron, and as large orders were placed for spelter, values rose steadily to about £18 2s. 6d., the month closing strong at the highest level. Makers on the Continent having sold freely and finding a scarcity of ores were inclined to hold for full prices. May witnessed a large demand from all consumers, including brass and yellow metal makers, and producers being sold out for some time ahead allowed dealers to command high prices, up to £18 10s. being paid for Virgin brands. Just at the end of the month a few speculative sales were made, which reduced values to £18 5s. for ordinaries and £18 7s. 6d. for specials. June saw the conclusion of peace in South Africa, which event was attended with large buying orders for galvanized iron, causing a rally in spelter values to £18 5s., and at this level the market remained until about the middle of July, when there was a spurt to £19 5s., based on the expectation of small supplies. Values remained steady until the first and second weeks of August, when there was a decline to £18 12s. 6d., owing to pressure of sales by dealers, but when the liquidation had ceased the continued good demand quickly caused values again to run up until by the commencement of September, £19 7s. 6d. was paid. A large trade was done round about this level, but when consumers had bought freely there was a setback, owing to Continental bear selling, and as low as £18 15s. was accepted. October saw an irregular market, but with a tendency toward a higher level, the highest point touched being £19 10s., but closing somewhat lower. A good business was done with Continental consumers, and galvanizers on this side also purchased with considerable freedom. November commenced quietly with £19 5s. to £19 7s. 6d., ruling as the nearest figures, but owing to a scarcity of near metal and an increasing demand, the price rose to £19 15s., only to fall later to £19 7s. 6d. In consequence of severe weather on the Continent, which delayed metal in transit, there was a recovery to £19 17s. 6d., which was practically the opening price for December, and was maintained throughout the month.

Breslau.—The price in marks for 50 kg. of zinc at Breslau for the 12 months of 1902 were as follows: January, 16·25@16·75; February, 16·75@17·75; March, 17·50@17·10; April, 17·50@17·80; May, 18@18·50; June, 18·25@18·75@18·50; July, 18·50@19·50; August, 19@19·25; September, 18·85@19·25; October, 19@19·50; November, 19·25@19·60; December, 19·50@19·10. The quarterly average prices of spelter, during 1902, as reported by the Royal Mining Office at Breslau, were as follows, the quotations being in marks (23·8c.) per 50 kg.:—

	1896.	1897.	1898.	1899.	1900.	1901.	1902.
First quarter.....	13·50	16·00	16·50	25·00	20·00	16·00	16·00
Second quarter.....	15·50	15·50	17·50	26·00	20·00	15·50	17·00
Third quarter.....	15·50	15·50	19·00	22·50	18·00	15·00	17·50
Fourth quarter.....	11·10	16·50	22·00	19·50	17·50	15 00	18·00
Average.....	15·12	15·87	18·75	23·25	18·87	15·38	17·13

of both primary and secondary crystals. The primary crystals are similar to those of pure zinc, but the secondary crystals are surrounded by what is probably a solid solution of lead in zinc. The fractured surface is similar to that of pure zinc. Zinc containing 0·5% Cd consists of small crystals of a cadmium-zinc alloy surrounded by zinc. The fractured surface is very finely crystalline. In zinc containing 0·5% Fe, the latter separates out in the crystalline form; it does not appear to form a true alloy with zinc. It probably is dissolved by molten zinc, and on cooling it is thrown out again as crystals of iron. The fractured surface is fibrous.

BLENDE ROASTING.—E. Prost and E. Lecocq[3] investigated the roasting of zinc blende containing fluorspar and found that a portion of the fluorine of the latter is set free in the state of hydrofluoric acid which is very harmful to the lead chambers when the furnace gases are employed for the manufacture of sulphuric acid. This is important to know, inasmuch as zinc ores frequently contain fluorspar.

The increasing importance to the zinc smelter of ores containing lead and silver, which may be partially recovered as by-products from the residuum remaining after distillation of the zinc, attracts attention to the behavior of those metals in the zinc smelting process. It is well known that in roasting galena there is a large loss of lead by volatilization which is the larger the higher the temperature in the furnace. In roasting galena the lead sulphide goes largely into the form of sulphate which can be completely decomposed only by means of silica, but this involves a high temperature and the loss of lead is so large that the practice of slag roasting has now been generally abandoned, at least in the United States. The temperature required for the desulphurization of zinc blende is also high and when the ore contains lead, as is the case with most of the ore now treated by European smelters, the loss of that metal by volatilization is important. What such loss may amount to has recently been investigated by K. Sander,[4] who reported the following results:—

Sample.	I.	II.	III.	IV.	V.
	%	%	%	%	%
Loss in weight	9·90	8·60	9·65	9·70	9·80
Lead assay, raw ore	9·84	11·38	6·60	7·73	6·00
Lead assay, roasted ore	9·88	11·47	6·10	6·98	5·20
Lead volatilized, per cent	9·53	7·98	16·44	19·05	21·80

The determinations of lead were made gravimetrically.

The lead in zinc blende exists almost always as sulphide, which is changed to oxide and sulphate in the roasting. The latter compounds react with the still undecomposed sulphide, forming sulphur dioxide and metallic lead, which volatilizes. Lead sulphide and oxide are also directly volatile, though at a higher temperature than the metal.

The volatilized lead compounds are partially recovered in the dust chambers of the furnace (probably to a very small extent, in view of the great difficulty of condensing and settling lead fume), partially by the acid dripping

[3] *Bulletin de l'Association Belge des Chimistes*, XVI., ii., 99 to 104.

[4] *Berg- und Huettenmaennische Zeitung*, LXI., xlv., 561, Nov. 7, 1902; *Engineering and Mining Journal*, Dec. 6, 1902.

Joseph P. Cappeau, of Joplin, Mo., patented[6] a roasting furnace of the Ropp type in which the roasting hearth is supported on transverse beams, so that the space beneath is clear. The stirring carriage passes beneath the hearth, the rake arm protruding upward through a slot in the usual manner. Tripping gates are arranged in the slot to keep the latter closed and regulate the admission of the air.

William A. Lorenz, of Hartford, Conn., also patented[7] a roasting furnace of the Ropp type, but the hearth is covered by twin arches, with a slot between them, the arches being supported by transverse overhead beams, so that the stirring carriage passes over the roof of the furnace instead of under the hearth as in the case of the Ropp and Cappeau furnaces.

RETORTS.—Increasing attention is given to the manufacture of the retorts, the aim being to improve the quality, which is important inasmuch as they are the key to success in the distillation process. The proper ageing, or rotting, of the clay increases greatly its plasticity and diminishes the tendency to crack in drying and firing. Just why this should result is not clear. E. C. Stover, in a recent paper[8] attributes it to a readjustment of the affinities in the batch, brought about by bacterial action. He has detected a bacillus in clay mixtures which produces hydrogen sulphide and develops well at from 37° to 38°C. If a fresh mixture be allowed to stand in the slip state, the fermentation will be complete in from six to twelve weeks, according to temperature, etc., but if inoculated with organisms, the change is complete in from two to four weeks under the same conditions. The properties of the St. Louis fire clay, which is used exclusively by the Western zinc smelters, have been investigated exhaustively by Dr. Otto Mühlhaeuser,[9] who finds that although the clay is of satisfactory refractoriness, corresponding to Seger cones 30 to 31, it is of a character which leads to rather porous retorts.

DISTILLATION.—Considerable attention, especially in England, has been directed to the Picard & Sulman method of zinc smelting, which has been applied on a commercial scale at Cockle Creek, N. S. W., whence consignments of spelter have already been received in England. Before the erection of the works in Australia, the process was given a trial at the Emu works, in Wales, where upward of 4,000 tons of ore were treated during 1901. Its details were communicated by the inventors, Messrs. H. Kirkpatrick Picard and H. Livingstone Sulman, in a paper entitled "A Dry Process for the Treatment of Complex Sulphide Ores," read before the Institution of Mining and Metallurgy, June 19, 1902, of which paper the following is an abstract:

"The roasted ore is mixed with about 20% of its weight of crushed coking coal, and the mixture is briquetted in any suitable type of machine, pitch or other carbonaceous material being employed as binding agent. The briquettes are then distilled in the ordinary manner and in the normal time. They coke into coherent masses and thereby form a skeleton which holds up the particles of reduced lead and the corrosive matte and slag, and thus protect the walls

[6] United States Patent No. 691,112, Jan. 14, 1902.
[7] United States Patent No. 691,787, Jan. 28, 1902.
[8] *Transactions of the American Ceramic Society*, 1902, IV., 193 to 198.
[9] *Zeitschrift fuer angewandte Chemie*, XVI., 148, 222, 273.

at Stolberg, 24% Pb was treated without difficulty by the usual method of smelting.[10]

Mr. Kiessling's views are shared by the other metallurgists of the Overpelt works, of whom Mr. Wilhelm Schulte has patented the process of replacing part of the coal used as reduction material by tar, asphalt or some other liquid or liquefiable hydrocarbon, whereby it is claimed that the quantity of coal can be greatly reduced, increasing the capacity of the retort for ore and enabling the smelting of more corrosive ores. For example the use of 25% of coal with ore mixed with 3% of tar is said to be as effective as 50% of coal without the tar. When the charge is heated, finely divided carbon separates from the hydrocarbon before the temperature at which reduction of zinc oxide begins, and enveloping every particle of ore insures a satisfactory reduction of zinc oxide and renders infusible the slag-forming elements.[11]

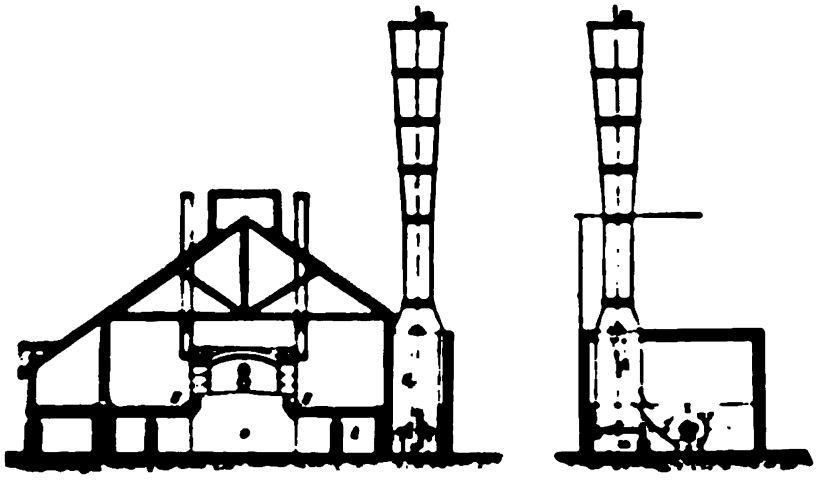
E. Prost, J. Charon, and M. Marissal[12] tested residuum from the distillation of a charge containing 6·64% Pb and 131 g. of silver per 1,000 kg. On screening the residuum 73·78% of the total lead was recovered, of which 37·7% was present in the fine material which passed a 2-mm. sieve, the fine material containing 57·8% of the total silver. On treating the cinder by amalgamation, it was found that about 13·5% of the total lead existed in the metallic state.

Karl Sander[13] made experiments as to the effect of barium sulphate in the ore subjected to distillation. He charged 10 retorts with roasted blende containing 9·2% of barytes and 10 more with ore free from barytes. The residues from the former assayed 2·08% Zn; those from the latter 2·92% Zn. A repetition of the experiment gave 2·70% and 3·54% Zn respectively. These experiments confirm the results of Prost and others to the effect that contrary to the general belief the calcium and barium sulphates do not interfere with the reduction of zinc oxide.

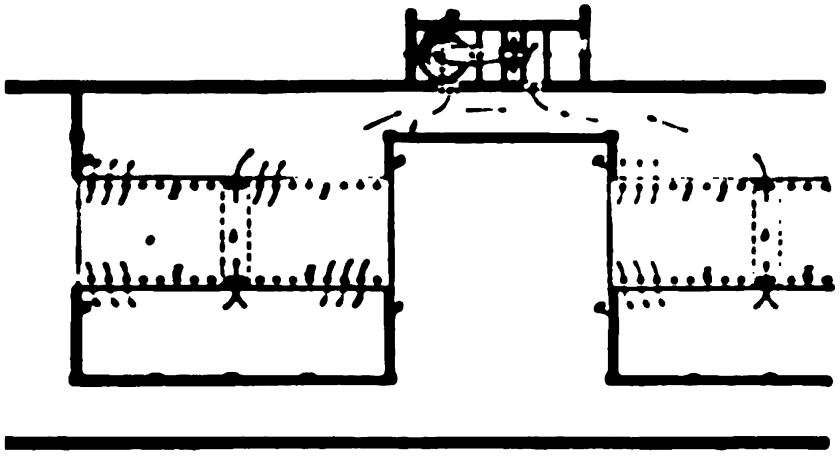
A new arrangement for the ventilation of the distillation furnace houses installed at Overpelt, Belgium, was described recently by Kiessling.[14] The Overpelt smeltery has two large furnaces, with three rows of muffles, in each house, as shown in the accompanying engraving. (Figs. 1 and 2.) The working floor is 2·5 m. above the ground level. The ashes drawn from the retorts are dropped into the chutes *xx*, falling into a roomy cellar. Formerly the chutes had gates, so that there would be no draught through them, but in spite of the hoods arranged in front of the furnace the development of dust and smoke during the maneuver was so great that the men were much inconvenienced. The closed chutes had the disadvantage moreover that sintering or easily fusible charges gave residues which would cake together and cause difficulty in removal. In the present arrangement the ashes are dropped directly into the cellar. The cellar is shut in with walls and a wall-closing sliding iron door *a*. The air from the cellar is exhausted by means of a fan *r*, which is connected with the cellar by the canal *k*, and discharges through the tube *s* into a chimney, which is 20 m. high.

[10] *Berg- und Huettenmaennische Zeitung*, LXI., xxxviii., 482, Sept. 19, 1902.
[11] French Patent No. 318,265, Jan. 31, 1902: United States Patent No. 718,222, Jan. 13, 1903.
[12] *Bulletin de l'Association Belge des Chimistes*, XVI., i., 41 to 54.
[13] *Berg- und Huettenmaennische Zeitung*, LXI., 485.
[14] *Berg- und Huettenmaennische Zeitung*, LXI., xxxviii., 476.

[illegible] diameter at top and bottom, narrowing in the lower third. The [illegible] diameter and makes from 5 to 6 r.p.m., exhausting about [illegible] cu. ft. of air per second. With this installation the ventilation is excellent, moreover there is the advantage that the hot air is drawn away from the [illegible] furnaces, making it more comfortable for the men, with the result that



[illegible] VENTILATION AT THE ZINC SMELTER AT [illegible], BELGIUM



[illegible] VENTILATION AT THE ZINC SMELTER AT [illegible], BELGIUM

[illegible]

L. Braunfels, of Frankfurt am Main, Germany,[16] mixes the ore with coal dust and makes into briquettes, which are then heated sufficiently to expel tarry matter. The zinc is then distilled from the briquettes in an iron retort, a vacuum being induced, and a current of carbon monoxide being finally passed through to lead the zinc vapor to the condenser.

C. H. T. Havemann, of Paris, France, patented[17] a process of decomposing mixed sulphide ore by means of molten iron, the reduced zinc being volatilized and the lead tapped off.

H. M. Taquet, of Argenteuil, France, proposes[18] to roast zinc blende to neutral and basic sulphate and distil with admixture of carbon and lime (or calcareous calamine) according to the reaction:—

$$ZnSO_4+CaO+5C=Zn+CaS+5CO.$$

DISTILLATION FURNACES.—In Upper Silesia a new plant is in course of construction at Hohenlohehuette by the Furstl. Hohenlohe'schen Berg- und Huettenverwaltung. It is expected to be in operation about the end of 1903. This plant will be noteworthy for its departure from the common Silesian practice in smelting. It is to have six double furnaces, each with 192 muffles arranged in two rows. Furnaces of this type were tried at the Hohenlohehuette 10 years ago, and also at the Guidottohuette, but were abandoned. Since then all the furnaces at the Hugohuette have been installed with three rows of small muffles, which are reported to have given excellent results. These innovations indicate a tendency in Upper Silesia to approach the type of furnace used in Rhenish Prussia and Westphalia, which has been predicted by several well-known Silesian metallurgists in view of the increasing proportion of roasted blende used in the charge for distillation and the increase in the zinc content of the charge because thereof.

In the United States the use of the old direct-fired Belgian furnaces has been almost entirely abandoned by the Western smelters, Collinsville, Carondelet, Rich Hill and Girard being the only places where they continue in use. The Matthiessen & Hegeler Zinc Co. uses long, gas-fired furnaces, and the Illinois Zinc Co. uses Siemens furnaces, modified by Neureuther, as previously described.[19] This company has abandoned the large elliptical retorts in favor of the smaller cylindrical ones of conventional dimensions. The natural gas smelters of Kansas use a long furnace, described previously in this series of reviews, which is essentially a modification of the Hegeler furnace. The Lanyon Zinc Co. has increased its number of furnaces with only 400 retorts, in place of the usual 600-retort Iola furnace. Several new distillation furnaces have been described during 1902.

Erminio Ferraris, of Monteponi, Italy, patented[20] in the United States the improved form of heat recuperative distillation furnace, which has already been described.[21] This furnace is in use at the works of the Societa di Monteponi in Sardinia, where it continues to give good results.

George G. Converse and Arthur B. De Saulles, of the New Jersey Zinc Co.,

[16] *British* Patent No. 17,415, Aug. 30, 1901.
[17] *British* Patent No. 10,105, May 15, 1901.
[18] *German* Patent No. 137,004, March 21, 1901.
[19] THE MINERAL INDUSTRY, X., 167.
[20] United States Patent No. 714,685, Dec. 2, 1902.
[21] THE MINERAL INDUSTRY, X., 999.

rates is more valuable than spelter or zinc oxide. The zinc vapor issuing from the retorts expands in the condensers while still at the temperature of volatilization and condenses immediately in the form of dust.

Samuel Davies, of Iola, Kansas, patented[25] the process of smelting zinc with the use of natural gas as reduction material instead of coal and coke, the gas being introduced into the retorts through a pipe inserted in the latter nearly to the rear end. It is claimed that this method will have the advantage of avoiding the introduction of sulphur into the charge and also of increasing the capacity of the retorts for ore. Both of these claims are undoubtedly true, but for other considerations the process does not appear practicable.

Oskar Nagel, of New York, patented[26] a method of distilling zinc ore in a blast furnace. He reports that he has found in his experiments that zinc vapor diluted with nitrogen will always condense to dust instead of to liquid metal, and, moreover, that if in addition to the inert gas there be present oxygen or carbon dioxide, a corresponding part of the dust will be immediately oxidized. If inert and oxidizing gases be excluded from the furnace the zinc vapor may be condensed to spelter. The new process consists in distilling ore mixed with coal in an atmosphere of water gas, this being an active reducing agent, which is preferably heated before being introduced into the furnace, thereby doing away with the necessity of using other fuel and overcoming the difficulty which other experimenters have found, namely, the dilution and oxidation of the zinc vapor by the agency of combustion gases. Coal mixed with the ore is employed only for the purpose of reducing any gases which become oxidized by the reduction of the zinc oxide. The zinc vapor is obtained in as concentrated condition as in the ordinary process of distillation, and condensation to spelter is readily effected, a yield of from 90 to 95% of zinc being obtained. The water gas, which contains approximately equal volumes of carbon monoxide and hydrogen, having been prepared by well-known methods, is heated by ovens by means of the waste gases coming from the condensation apparatus. The water gas is preferably forced into the furnace by means of a blower. The furnace in which the reduction is effected may be constructed similarly to the ordinary blast furnace for lead smelting, or upon the lines of furnaces used for distilling mercury. It should be provided with the usual charging hopper and with a slag tap at the bottom. The tuyeres will be located about one-third of the height of the furnace from the bottom. Leading out of the furnace near its top is a fire-clay lined flue through which the vapor is conveyed to the condensation apparatus. With a furnace of capacity for 25 tons of zinc oxide per day, about 5 tons of the oxide will be reduced in from 4·5 to 5 hours, the water gas being introduced at a temperature of about 1,000°C. In practice it is found that 1·5 tons of water gas containing 1·4 tons of carbon monoxide and 0·1 ton of hydrogen, occupying a bulk of 10,415 cu. m. at 1,000°C., will be sufficient for the reduction of 8·1 tons of zinc oxide.

Dorsemagen proposes[27] to smelt a mixture of calcined siliceous zinc ore and coal in an electrical furnace (see Fig. 3), reducing and volatilizing the zinc, which is condensed in the ordinary manner, and reducing the silica of the ore

[25] United States Patent No. 694,947, March 11, 1902. [26] United States Patent No. 699,369, May 13, 1902.
[27] German Patent No. 128,535, Dec. 25, 1900.

...on carbide. The charge in the crucible is heated by the carbon electrodes, ... metal runs off into the condenser extending horizontally from the upper ... of the crucible (retort) and the silicon carbide remains behind. The ... temperature of the arc is said to be only a little above that required ... zinc. The same idea is proposed for the reduction of ... ferrosilicon being obtained instead of silicon carbide. This ... to be adapted to continuous operation, the ferrosilicon being tapped ... hour, together with such slag as might be formed.

... Alfred J. Ash, of Petersmuir, England, patented[1] ... for refining crude spelter, which is substantially the same as the

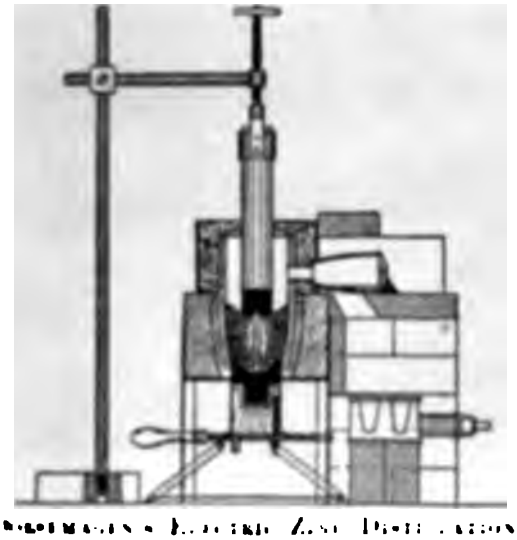


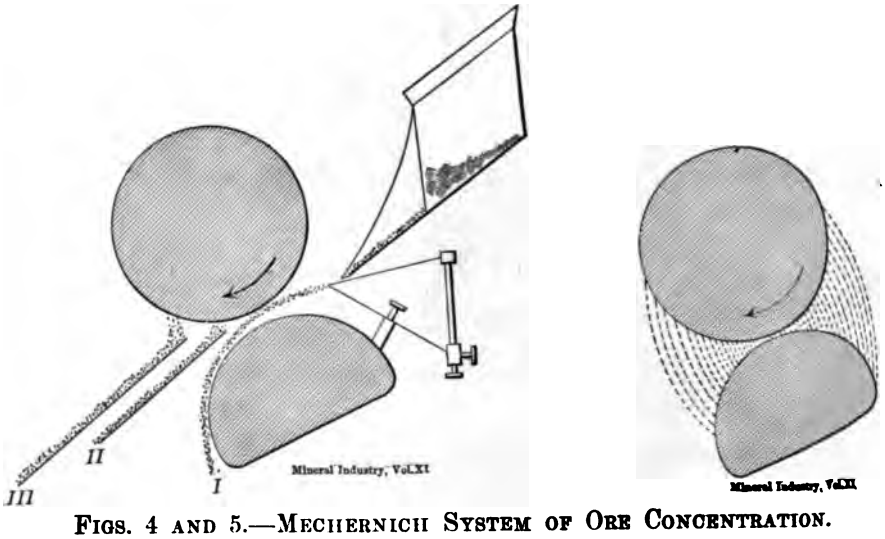
FIG. 1.—[illegible]

... reverberatory furnace employed for that purpose. In the charge is ... a mixture of oxide, so that the metal ... to form ... the coal when active ... remains behind in the ... The ... may be tapped off separately. Refined spelter is drawn from the ...

TREATMENT OF MIXED SULPHIDE ORES

... a large number ... [illegible] ... [illegible] ... [illegible]

MAGNETIC CONCENTRATION.—In the Mechernich system the ore is delivered by an adjustable chute between two magnetic poles, the upper one of which (the north pole) is rotated. (See Figs. 4 and 5.) As the ore arrives in the magnetic field the permeable particles are attracted by the north pole and are carried around by it into zones of progressively diminishing intensity until the centrifugal force imparted to the particles overcomes the magnetic attraction and they fall into collecting chutes, being classified according to their magnetic properties. The non-magnetic material falls directly into a chute close against the lower pole. This arrangement is claimed to have the advantages of dispensing with belt carriers, which weaken the magnetic field, and also of permitting the use of small magnetic fields and very narrow air spaces, thus minimizing the loss of energy and making it possible to attract feebly magnetic particles by a very weak current. The rotating pole being the only moving part of the machine, wear and tear is very small. Hassreidter reports[29] that in separating blende and



FIGS. 4 AND 5.—MECHERNICH SYSTEM OF ORE CONCENTRATION.

siderite from the Upper Harz, the grains being of 0·5 mm. size, 98·7% of the zinc has been recovered. With dolomitic Silesian blende of from 2 to 3 mm. size, the recovery was of 91·8%, which was increased to 93·5% by reducing the grains to 2 mm. In treating ore from Broken Hill a yield of 81% of the lead and 69% of the zinc was obtained. A plant of this type installed at Broken Hill for the treatment of middlings assaying 28% Zn, 10% Pb and 9 oz. silver per ton furnishes a product with from 44 to 45% Zn and 4·5% Pb.

The magnetic separation of zinc blende from mixed sulphide ores by means of the Wetherill machines, which has already been done with more or less success at Broken Hill, N. S. W., is now being carried out as a regular process by the Colorado Zinc Co., at Denver, Colo., treating ore from Leadville. The ore is first broken by means of a Gates crusher, and is then reduced by rolls to 30-mesh size. This product is distributed among eight Wilfley tables, which sep-

[29] Journal of the Society of Chemical Industry, Sept. 30, 1902.

sulphite by a suitable precipitant. The zinc is then precipitated as oxide by means of lime, and the resulting solution of calcium chloride is treated with the sodium sulphite obtained as described above, reproducing sodium chloride.

Jabez Lones, E. Holden and Joseph Lones, of Smethwick, England, patented[36] the process of leaching zinc oxide from ore by means of a solution of hot acetic acid, purifying the solution and then precipitating zinc as sulphide by means of hydrogen sulphide, prepared by leading the sulphurous acid, evolved in roasting the ore, through a chamber filled with red hot coke and aqueous vapor. In an alternative process the zinc is dissolved with a solution of caustic soda and is precipitated with sodium sulphide.

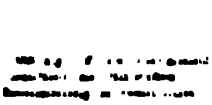
Herman C. Meister, of St. Louis, Mo., patented[37] a process of recovering zinc from galvanizers' skimmings, which consists of treating skimmings with the oxide of an alkali, or of an alkaline earth, preferably common lime, in the presence of moisture. The skimmings and lime are ground together in the proportion of from two to five parts of the former and approximately one part of the latter, depending upon the quantity of chlorides present in the skimmings. The mixture is then thrown into a tank of water, where chemical reaction takes place, which is facilitated by heating, although this is not essential. The zinc is oxidized by the lime, the latter being transformed into calcium chloride. The zinc oxide is filtered off and treated for the recovery of zinc by distillation in the usual manner. In another patent[38] the process of treating zinc skimmings in the same manner, but with the use of sodium carbonate instead of lime, is covered, the zinc in this case being converted into zinc carbonate.

James W. Neill and Joachim H. Burfiend, of Salt Lake City, Utah, patented[39] the process of recovering zinc by treating roasted ore with sulphur dioxide, blown through a series of special vats in which the ore is held in suspension in water. The solution of zinc bisulphite thus obtained is boiled down to precipitate zinc as monosulphite, a portion of the sulphur dioxide being thus liberated and returned to the process. The precipitate of zinc monosulphite is calcined for the production of zinc oxide. The claims of the patent relate especially to the apparatus employed and the method of carrying out the process.

ELECTROMETALLURGICAL PROCESSES.—The Hoepfner process, improved by Dr. Mond, continues in use at Winnington, near Chester, England, but electrolytic zinc is nowhere else produced. The various processes proposed in 1902 have presented no promising new suggestions.

Borchers and Dorsemagen chlorinate raw ore in the presence of salt solutions (sodium chloride, magnesium chloride) at from 30° to 40°C. in revolving lead-lined barrels, into which chlorine gas from a subsequent stage of the process is introduced through the trunnions. Lead, zinc and silver chlorides are then leached out with hot water, or the hot dilute liquors of the process. From the residuum the free sulphur is distilled off under steam pressure by Schaffner's method. The final residuum which still contains a large percentage of zinc in the form of undecomposed blende together with the greater part of the silver, is then to be worked up as a zinc ore in the ordinary manner. The results of

[36] British Patent No. 10,865, May 25, 1901.
[37] United States Patent No. 714,502, Nov. 25, 1902.
[38] United States Patent No. 714,503, Nov. 25, 1902.
[39] United States Patent No. 703,393, June 17, 1902.



The Progress in the Zinc Industry in Missouri during 1902.

By Frank Nicholson.

Perhaps the most striking fact in the history of the Joplin zinc district du ing 1902 is the unmistakable decline in the productive capacity of the outlyir districts, and a counterbalancing increase in the production of the older camp

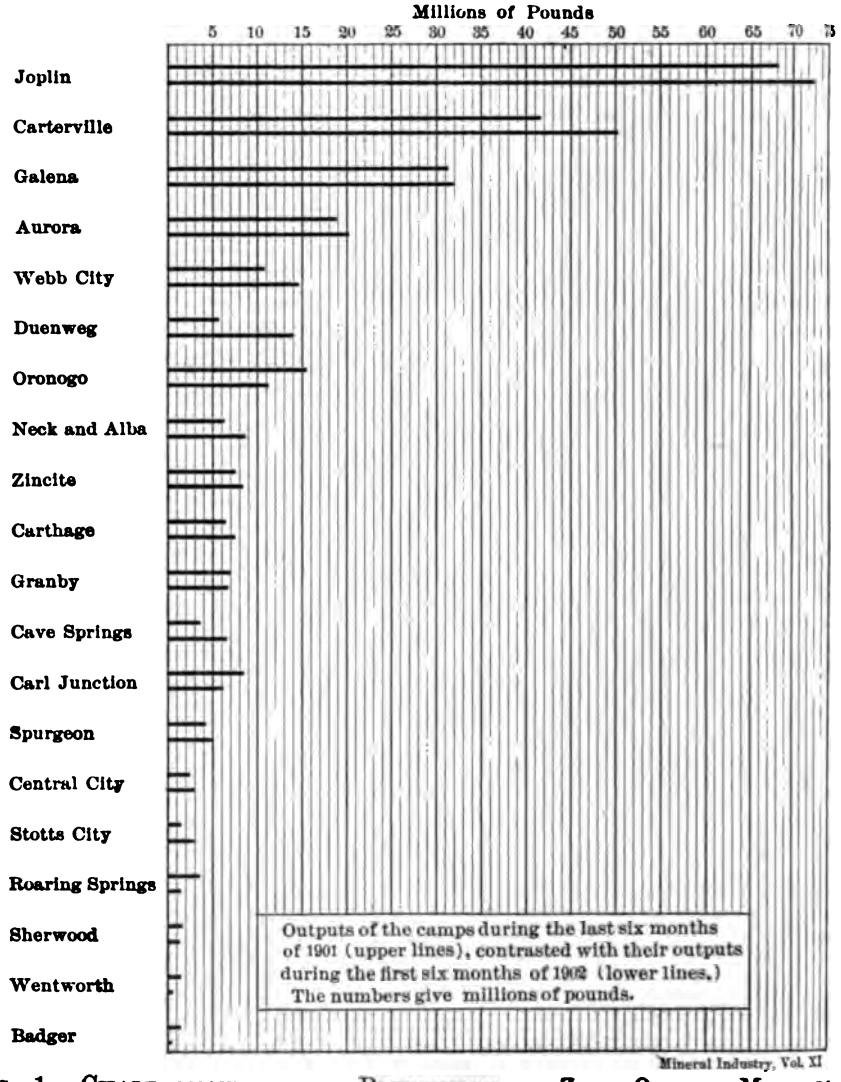


Fig. 1.—Chart showing the Production of Zinc Ore in Missouri by Districts.

The accompanying chart (Fig. 1) gives the production of the various district for the last half of 1901 and the first six months of 1902.

The largest gains were made by Carterville and Duenweg, followed by Joplin and Webb City. The greatest decline is shown by Roaring Springs, Carl Junction

contracts to deliver all ore produced to this purchasing company, but t talists financing the company refused to undertake the work until at le of the output was under contract.

The plan attracted a great deal of attention from the smelters and ore and resulted in a material advance in the price of ore. This advance price of ore cooled the enthusiasm of the operators who, when ore re $35 basis, no longer cared to enter into contracts with a company whose purpose was to prevent excessive fluctuations in the price and keep it a as possible at $30 per ton. The plans of the ore purchasing company w necessarily postponed until such time as the condition of the market

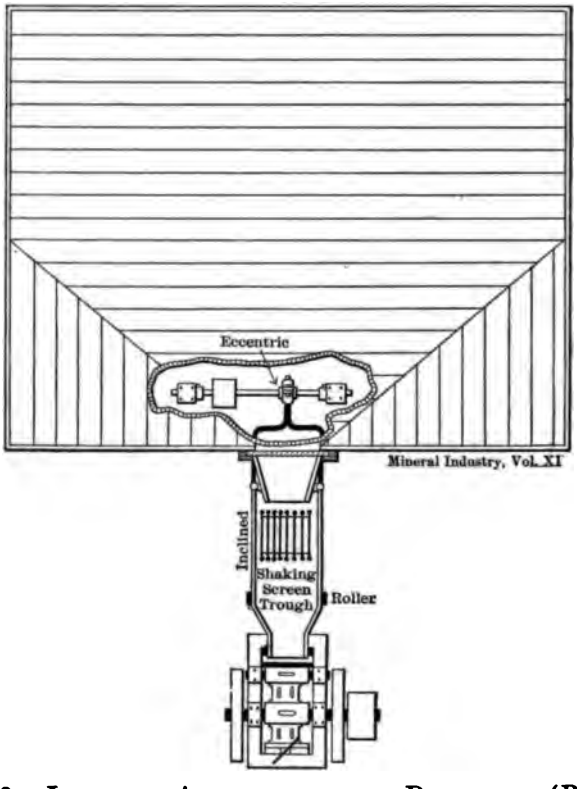


FIG. 2.—IMPROVED ARRANGEMENT OF DECKHEAD (PLAN).

again make its efforts desirable. It is probable that some such plan w mately be consummated, and will result in great benefit to the operators as to the smelters, as both are interested in a steady market.

There were slight changes in mining methods, and the general situatio as to mining and milling in this district shows but trivial variation fr practice of 1901. The only change to be noted in the mining practic use of heavier hoisting devices and buckets of larger capacity. Thus l *buckets* have generally been added to the new plants in place of the buckets formerly used. This, of course, has necessitated heavier ca

or hoisting engines. The number of air drills used has greatly increased the past year.

a few new mills have been built during the year, but a large number of ve been moved to new locations. The number of operating mills st the same as a year ago. The chief changes in milling practice have the more general use of the Wilfley tables and a different and better ystem of the deckhead. The most improved mills now being built raise e from the mine to the top of the derrick, about 40 ft. above the collar

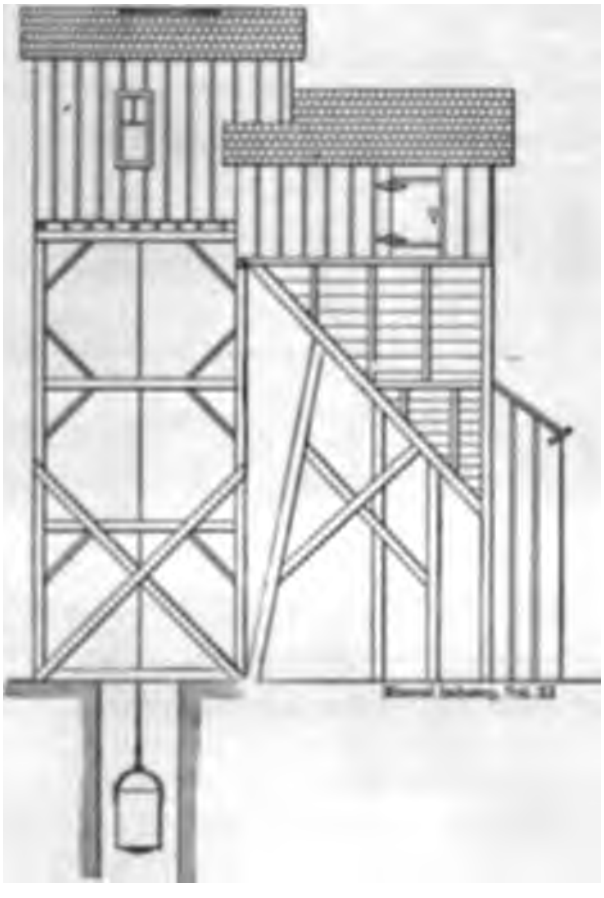


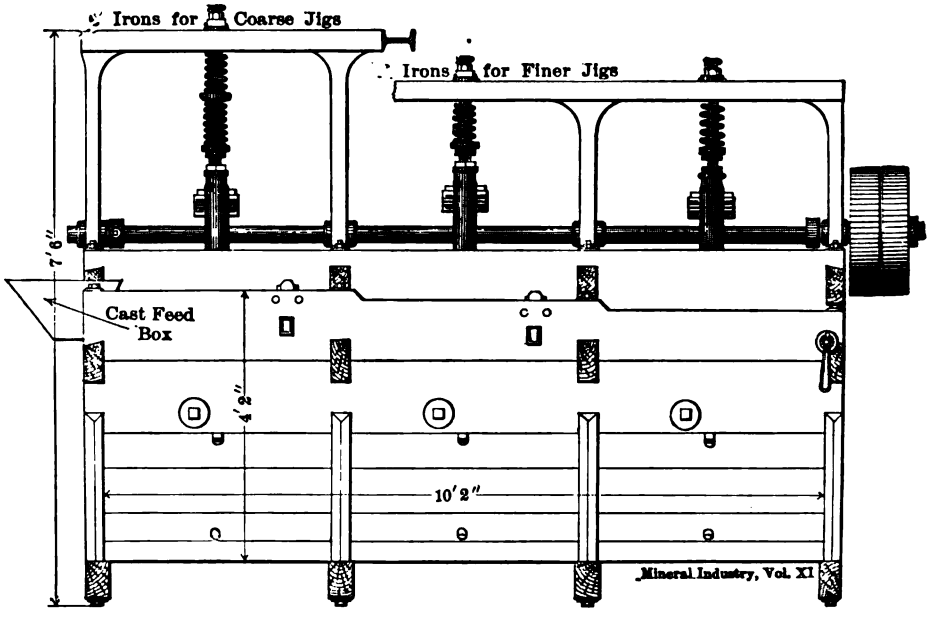
FIG. 1.—IMPROVED ARRANGEMENT OF THE HEAD OF [illegible]

shaft. The ore is dumped [illegible] and the coarser [illegible] to be crushed, which delivers [illegible] this ore is, with a [illegible] belt and follows the [illegible] mount of the deckhead [illegible] more uniformly than is possible [illegible] These accompanying [illegible] *(Figs. 2 and 3)* show this style of deckhead

During the past year a number of minor improvements have been made in milling appliances, among others the New Century jig has been improved and simplified. Figs. 4, 5 and 6 show the present type of this machine. The improvements are chiefly of mechanical construction, which makes the jig simpler and more certain in its action. These jigs have not as yet gained a foothold in the Joplin district, although exhibition tests have been all that could be desired.

During the past year the Joplin Separating Co. has been operating its plant continuously, and it is the intention to enlarge its capacity during the summer of 1903.

No Joplin ore was exported during 1902, although there was serious talk of export during the early part of the year. A marked drop in the price of ore set in about September, when the top price was $39·50. From that time a steady



FRONT ELEVATION OF A THREE COMPARTMENT JIG.

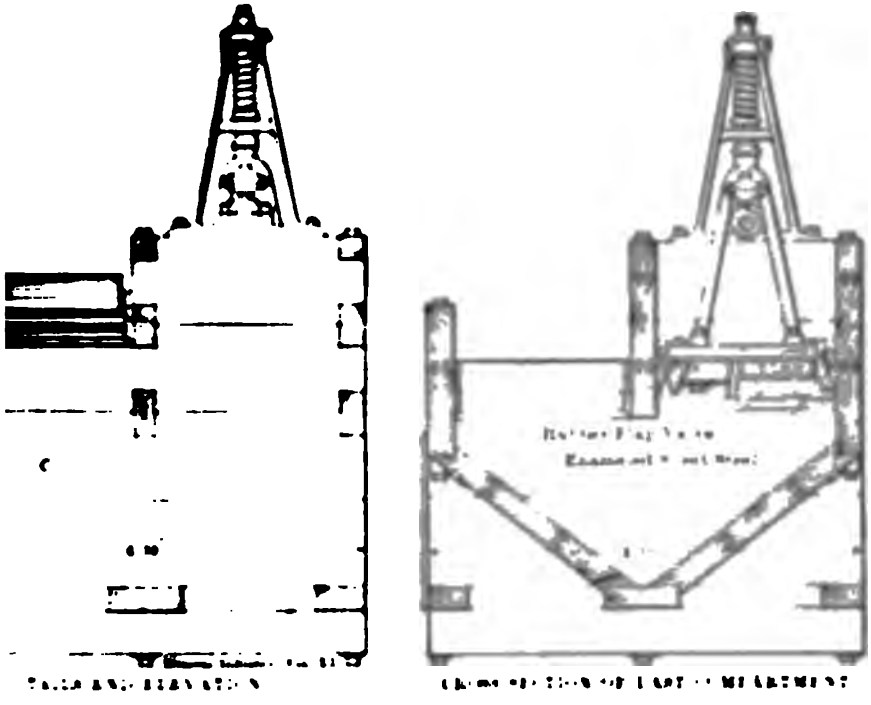
FIG. 4.—IMPROVED NEW CENTURY JIG.

decline ensued, until on December 8 the top price had dropped to $33, and the basis to $28 per ton for 60% ore. This decline was assisted by a car famine that became acute about the middle of November, and seems to have been brought about partly by the general prosperity of the country and the inability of the railroads to furnish the requisite cars to handle their offerings of freight, and in some degree by the slowness of the smelters in unloading the cars.

On Dec. 8, 1902, there was a visible supply in the ore bins of the district amounting to about 10,000 tons, half of which had been bought and paid for by the smelters, but which, on account of the shortage of cars, still remained in the bins of the producers. This large accumulation undoubtedly tended to unsettle prices. The Miners' Association thereupon determined to export at least a portion of this surplus. With this idea in view bids were

[illegible] tons of ore for export, and producers were requested to consign at a price that would make it possible to take the ore out of the [illegible]. Several meetings of the producers were held, and 1,000 tons of ore were [illegible]. A contract for export was awarded to me at a flat price of [illegible] without deduction for iron or moisture.

[illegible] the great difficulty in the matter of export has been the fact that [illegible] in possession of sufficient detailed information to determine accurately the cost of exporting one ton of ore from Joplin to Antwerp. I undertook [illegible] with the intention of determining accurately the [illegible] of export enumerated below. These items are calculated for [illegible] tons of 2,000 lb each, which was the total tonnage exported. The



[illegible]

[illegible] per ton 2.50

The question of difference in assays is one of considerable interest, as the methods used in Joplin and Antwerp are altogether different, the ferrocyanide method obtaining in Joplin, while in Antwerp, Schaffner's method is generally used.

The export was effected in two shipments of 500 tons each. The assays were as follows: *First shipment:*

Joplin assay, 58·85%. Analysis upon which settlement was made, 58·7735%. Loss per ton, $0·0765.

Second shipment:

Joplin assay, 58·34%. Analysis upon which settlement was made, 57·645%. The loss in this case per ton was, $0·695. The average loss was therefore, $0·3857.

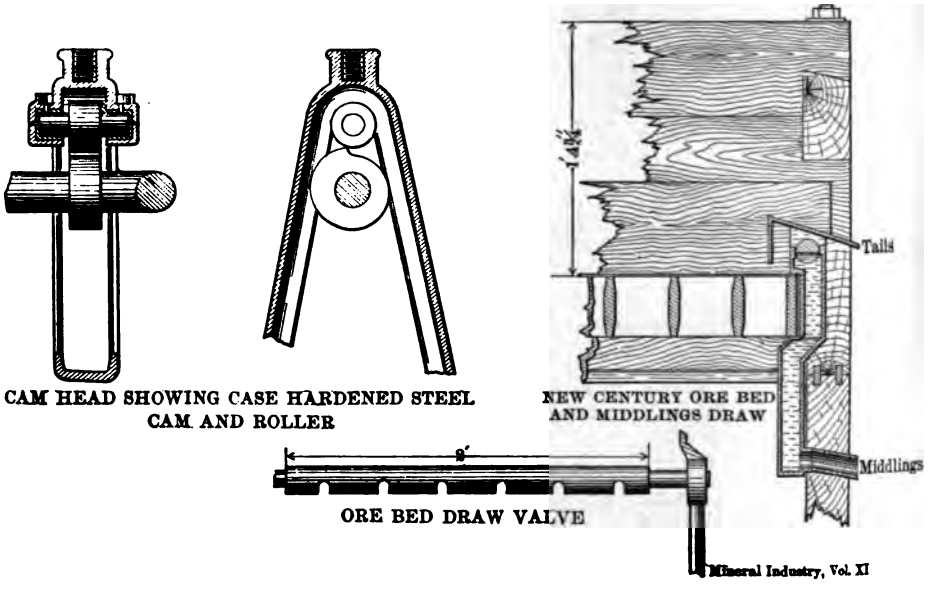

CAM HEAD SHOWING CASE HARDENED STEEL CAM AND ROLLER
NEW CENTURY ORE BED AND MIDDLINGS DRAW
Tails
Middlings
ORE BED DRAW VALVE
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FIG. 6.—IMPROVED NEW CENTURY JIG.

Tabulating these charges and assuming a purchase price in Joplin of $30 per ton for zinc concentrates, it may be considered fairly approximate to place the total cost of exporting one ton of zinc concentrates from Joplin to Antwerp at $8·2971.

	Total for Shipment.	Per Ton.		Total for Shipment.	Per Ton.
Joplin:			Antwerp:		
Hauling and loading	$561·11	$0·55	Draftage, 0·29 of 1%		$0·087
Switching expenses were	329·51	0·3224	Incidentals (covering interest, cables, reception charges, etc.)	$265·00	0·259
Incidentals	177·40	0·173	Difference in assays		0·3857
Railroad freights		5·80			
Loss in transit		0·72	Total cost of exporting 1 ton of ore		$8·2971

Comparatively little Eastern capital has been invested in the district during the past twelve months, and of that which was invested, the greater portion came from Boston.

The price of properties has advanced fully 25% over the figures obtaining in 1901, and for this reason, in part at least, is owing the fact that Eastern capital has kept out of the district. The Joplin mine is a plant of quick profit. From the date of sinking the shaft to that of the exhaustion of the property the capital occupies from one to five years. The result is that the income and more money in the Joplin district comes it so quickly as to bewilder the. Larger sums are lost in the Western mining districts, but the process is a long drawn out that the loser gets used to it.

As to the occurrence of the Joplin deposits becomes better understood and the methods of investigation are adapted to the requirements of the existing conditions fewer mistakes are made in the determination of the value of properties and as a field for investment the Joplin district becomes more inviting. The boom of 1899 has passed, and the business has settled down to a conservative basis that is full of promise for the future.

A REVIEW OF THE GENERAL LITERATURE ON ORE DEPOSITS DURING 1901 AND 1902.

By J. F. Kemp.

In several of the previous volumes of The Mineral Industry reviews have appeared which have outlined the progress of thought with regard to the structural features, classification and origin of ore deposits. The object of the reviews has been to present, in brief space, the gist of the more important contributions of the few preceding years. In the interval which has elapsed since the publication of the last article much has been done, and one may fairly say that interest in this attractive branch of geology has never been greater than at the present time. It is of the highest importance to keep active the minds of the mining fraternity, and to urge that records be made in the form of sketches and descriptions of significant phenomena in veins which often pass from sight with the advance of excavation, and are thus lost to science unless promptly noted.

Geologists and mining engineers in America are profiting in these later years by the great and notable literature which has grown up under the auspices of the State and National Surveys, in the proceedings of our scientific and technical societies, and in the columns of the mining press. Many of the larger reports, similar to those of Arthur Winslow on Lead and Zinc, published by the Missouri Geological Survey; and that of R. A. F. Penrose on Manganese, issued by the Geological Survey of Arkansas, have been encyclopædic in scope, and have become books of reference, certain to remain standard for many years. Other detailed monographs on particular districts have been especially valuable for their thorough treatment of special cases; while the shorter papers have furnished a vast array of facts upon which to base generalizations. The influence of all these sources of knowledge is apparent when one, while reading the later works, has a point of view established by familiarity with the earlier contributions.

The general progress of reasoning about ore deposits, and more particularly about vein formation, may be best set forth under the following heads: 1. The primary derivation and distribution of the metals in the earth. 2. The primary concentration of the metals in veins or other forms of ore deposits. 3. The secondary changes, rearrangements and enrichments of ore deposits.

1. *The Primary Derivation and Distribution of the Metals in the Earth.*— At the outset it is necessary to go back to the speculative hypotheses about the origin of the solar system. Of these the nebular hypothesis, despite the objections

ago emphasis was laid by them upon the contact zones and their ores in the Christiania district. To Waldemar Lindgren is due the credit of recognizing this character in certain copper deposits in the Cordilleran region of the West, and by him their characters were first described.[3] Subsequent papers have shown that the type is widespread, especially in Mexico and the Southwestern United States, and that contact, garnet zones of great magnitude have often been developed from limestone by the action of neighboring eruptives and by their contributions of silica and especially of copper ores. W. H. Weed[4] has given to those copper deposits which have formed in some special bed near the contact, the name of the Cananea type, after the notable occurrence of ore in the northwestern claims of the Cananea group, Sonora, Mexico. Great developments of this same type have been also described from San Pedro, New Mexico.[5]

The bearing of all these phenomena on the formation of veins lies in the fact that eruptive rocks have thus been shown to contribute vast quantities of silica, undoubtedly in association with water or its dissociated elements and with metallic sulphides and oxides. The inference, therefore, follows that, had not this silica been locked up in combination with lime next the eruptive, it would have circulated to more remote points and developed veins. A well established point of departure has thus been afforded for reasoning about more obscure phenomena.

Another extremely important contribution to the study of contact effects[5a] has been made by Joseph Barrell, who has shown the extraordinary shrinkage which has taken place in the conversion of calcium carbonate into a mass of silicates. The loss of the carbon dioxide does not find entire compensation in the entrance of silicic acid and a more or less open-textured rock is thereby afforded, which may well be a place of deposition of ores, subsequently introduced.

In the previous review in THE MINERAL INDUSTRY by Dr. Raymond, a general statement was made regarding the papers which had been prepared up to the time of going to press two years ago. Several of these were important contributions to the general thesis that ores and gangue minerals in veins have been deposited by the meteoric waters, which percolate downward after falling as rain upon the surface, and which return again after a more or less protracted journey. The head afforded by a place of entry higher than the point of emergence has been urged as the chief cause of movement, and this is supposed to have been reinforced by the normal increase in the temperature of the earth with depth, which causes expansion and decrease in density in the uprising heated column, as compared with the descending cold one. The latter increment, however, has been shown to be practically negligible for 10,000 ft.,

[3] W. Lindgren, "Copper Deposits of the Seven Devils," *Mining and Scientific Press*, Feb. 4, 1899, 125; "The Character and Genesis of Certain Contact Deposits," *Transactions of the American Institute of Mining Engineers*, XXXI., 226, 1901.

[4] *Engineering and Mining Journal*, Feb. 14, 1903, 256. Presented also at the New Haven meeting of the American Institute of Mining Engineers, October, 1902.

[5] Yung and McCaffery, "The Ore Deposits of the San Pedro District, N. M." A paper read before the American Institute of Mining Engineers at the New Haven meeting, October, 1902. *Engineering and Mining Journal*, Feb. 21, 1903, 297.

[5a] Joseph Barrell, The Physical Effects of Contact Metamorphism, *American Journal of Science*, April, 1902, 279.

Cripple Creek district.[9] Very interesting connections have been shown by the late E. A. Stevens, of Victor, Colo., to exist between the eruptive dikes and the ore shoots. Thus, where certain kinds of dike rocks intersect fissured belts, the ore makes strongly.[10] All of these coincidences are highly suggestive to prospectors in other districts.

W. P. Jenney has suggested an explanation for certain blind veins, which are met in districts in the arid regions, by enunciating the principle of the "Mineral Crest." One belt of ores at Tintic, Utah, is known to become barren at a certain fairly definite altitude, although ore-bearing below this horizon. Jenney explains this crest as having been established by the neighboring gulches, which cross the line of the fractures. Ore-bearing solutions uprising when the topography was similar to its present relations, would be prevented passing a certain level by this side drainage.[11] The explanation coincides very well with the phenomena of the belt to which it is applied, but it has been controverted by S. F. Emmons and G. O. Smith,[12] with whose views, as expressed in the Tintic Special Folio, it is at wide variance, since they consider that the ore bodies were formed when the places of deposition stood at very considerable depths and beneath a great overlying load of rocks now removed. Nevertheless, Jenney's suggestion may well be borne in mind in the study of other districts.

The chemical reactions, by which ores and gangue minerals have been precipitated, have received the greatest amount of attention in the papers to be reviewed under the next head, because the reactions which are even now taking place near the surface are open to observation. In the past, and largely to-day, we are obliged to refer in a general way to diminishing pressures and temperatures. The precipitation of sulphides from metallic solutions may be obviously brought about by sulphuretted reagents, or, if the metallic salts are sulphates, as is highly probable in many cases, by reducing agents. Base sulphides like pyrite, FeS_2, may likewise be enriched by the reducing action of their own substance upon solutions with which they come into contact. Attacking this problem along the line of reducing agents, W. P. Jenney has published recently by far the most important paper of its kind.[13] The effects of carbon and hydrogen and their compounds are first discussed, then the sulphur compounds and their relatives, followed by a review of the individual metals of importance in this connection. Finally a table of the relative reducing efficiency of the several ores discussed is given as a summary. They range from hydrogen, which is taken at 100, down to magnetite, taken at 0·46. The great efficiency of the reducing action of the hydrocarbons, as compared with other minerals, comes out most forcibly, and the applications to many mining districts are set forth in the text. It can be readily understood from these facts why it is that bituminous

[9] T. A. Rickard, "The Formation of Bonanzas in Gold Veins," *Transactions of the American Institute of Mining Engineers*, Richmond meeting, 1901; "The Lodes of Cripple Creek," a paper read before the American Institute of Mining Engineers at the New Haven meeting, October, 1902.

[10] "Basaltic Zones as Guides to Ore Deposits in the Cripple Creek District, Colorado." A paper read before the American Institute of Mining Engineers at the Philadelphia meeting, May, 1902.

[11] W. P. Jenney, "The Mineral Crest; or, The Hydrostatic Level Attained by the Ore-depositing Solutions in Certain Mining Districts of the Great Salt Lake Basin." *American Institute of Mining Engineers*, 1902.

[12] G. O. Smith and S. F. Emmons. Discussion of the above. *Idem.*

[13] W. P. Jenney, "The Chemistry of Ore Deposition." A paper read before the American Institute of Mining Engineers, at the New Haven meeting, October, 1902.

descending surface waters. W. H. Weed[15] has urged that after the first deposition of a relatively lean pyritic vein material, the solutions changed once and probably oftener and enriched the older base sulphides by new deposits of metallic compounds. At the New Haven meeting of the American Institute of Mining Engineers, October, 1902, Mr. Weed presented a note regarding the enrichment of veins by ascending alkaline solutions, in which it was shown that Dr. H. N. Stokes of the U. S. Geological Survey had obtained in the laboratory the following reaction from pyrite and marcasite with CuO or other metallic oxides in a sodium bicarbonate solution:—

$$2FeS_2+6CuO+H_2O=3Cu_2S+Fe_2O_3+H_2SO_4.$$

This result is of far-reaching importance and makes it desirable to study the paragenesis of minerals in ore deposits with great care, since if a primary filling of some base sulphide like pyrite is in a vein, it may prove to be a reagent of great efficiency upon solutions entering later. Mr. Weed suggests that other ores such as enargite, polybasite, pearcite, proustite and pyrargyrite may be produced in this way, and that experiments are under way to verify the supposition.

The papers above cited, especially that of S. F. Emmons, have also dealt with the level of the ground-water in an important manner, and have served to emphasize its irregular upper surface. In broken ground it may stand very low, relatively to neighboring portions, being naturally drained away by lower outlets. Alteration, therefore, may extend to much greater depths in some places than in others.

The only remaining topic which might be touched upon in this review is the classification of ore deposits. A very interesting discussion upon this theme was started by the presentation of a scheme of classification before the Geological Society of America at the Washington meeting, December, 1902, by W. H. Weed. This and a second one by J. E. Spurr were afterward the subject of extended discussion before the Geological Society of Washington and were reported in the *Engineering and Mining Journal*, Feb. 14, 1903. These discussions are too detailed for reproduction here, but it may be said that in Mr. Weed's scheme the effects of eruptive intrusions and expiring vulcanism are especially emphasized, and that under five comprehensive heads types of ore bodies are established based on mineralogical characters. The five heads are, I. Igneous (magmatic segregations); 2. Pneumatolytic deposits; 3. Fumarolic deposits; 4. Gas-aqueous deposits; 5. Meteoric waters. Mr. Spurr establishes three "orders" as follows: 1. Original, formed during the cooling processes of igneous rocks; 2. Subsequent, formed from cold rocks; 3. Transitional. In the former scheme the growing appreciation of the rôle played by the eruptive rocks is manifest.

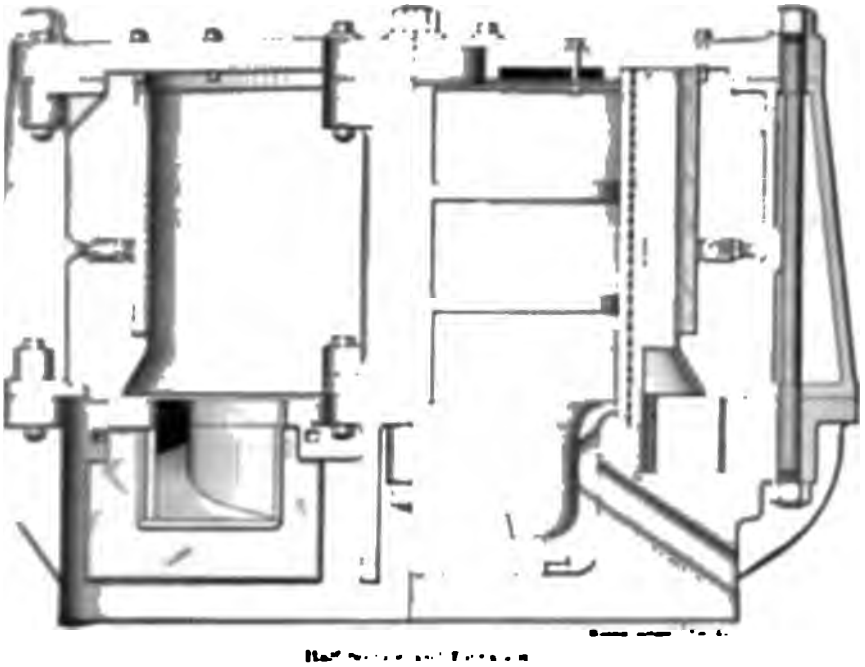
In addition to the papers mentioned above, many other important ones have appeared in which descriptions of particular districts are given, but only those have been discussed here which deal with the general principles of the science of ore deposits.

[15] W. H. Weed, "Ore Deposits at Butte, Mont.," *Engineering and Mining Journal*, April 18, 1903, 589.

REVIEW OF THE LITERATURE ON ORE DRESSING IN 1902.

By Robert H. Richards

Cambridge, Massachusetts.



the coarse copper escapes from the mortar at once, and is not subjected to continued stamping. In comparison with former types the effective discharge area is increased to a maximum, while the area of the permanent parts of the mill exposed to the abrading effect of the splash is reduced to a minimum. The capacity of the mill is greatly increased, the loss of slimes is reduced, the quality of the metal is improved, and the expense of renewing linings and abraded parts is appreciably diminished. The screens and splash-pan being easily removed, the mill is more accessible for inspection and repair than when partly inclosed on the sides by a permanent casing.

The Perfection Ore Crusher.[2]—This crusher is designed for laboratory use, and is a combination of jaw and roll crusher. The stationary jaw in ordinary crushers is replaced by an upper movable jaw and a steel roll; it can be adjusted to crush to 100-mesh size.

Mills in Australia.[3]—At the Great Boulder mine seven Griffin mills crushed 150 tons of auriferous sulphide ore per day from 1-in. through a 15-mesh woven wire screen; the ore contains less than 3% moisture, and the time includes all stoppages. Wages and repairs amount to from $0·42 to $0·46 per ton.

At the Lake View Consols and Kalgurli, Nos. 8 and 5 ball mills using 30 and 15 H.P. respectively, crushed from 50 to 55 tons and from 25 to 30 tons of ore per day respectively, from 1·5 to 2·5 in. through 40-mesh woven wire screens. Wages, repairs, and conveying to furnaces amount to from $0·26 to $0·30 per ton.

The screen analyses of the crushed ore were as follows:—

Great Boulder, Griffin Mills, 15-Mesh Screen.—On 20 mesh, 0·91%; through 20 mesh on 40 mesh, 3·92%; through 40 mesh on 60 mesh, 6·92%; through 60 mesh on 80 mesh, 3·10%; through 80 mesh on 100 mesh, 6·19%; through 100 mesh on 120 mesh, 4·74%; through 120 mesh, 74·10%.

Lake View Consols Limited, Ball Mills, 40-Mesh Screen.—On 60 mesh, 6·51%; through 60 mesh on 100 mesh, 26·23%; through 100 mesh on 150 mesh, 6·69%; through 150 mesh, 60·57%.

Kalgurli Gold Mines, Limited, Ball Mills, 40-Mesh Screen.—On 80 mesh, 24·86%; through 80 mesh on 110 mesh, 14·89%; through 110 mesh, 60·24%.

Concentrating Machinery.

The Sturtevant Toggle Separator.[4]—This separator consists of a series of four inclined screens arranged one above another in a box 6 ft. long, 2 ft. wide, which is agitated vertically by means of a toggle.

Screen vs. Hydraulic Sizing.[5]—S. I. Hallett calls attention to the enormous final losses in modern concentrating mills from the final *spitzkasten* overflow. While no remedy is recommended he thinks that the problems on all steps of concentration preceding *spitzkasten* have been solved, in other words, that vibrating screens eliminate the use of the classifier. The mill recently built at Silver-

[2] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 420.
[3] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 40. Frank Moss.
[4] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 558.
[5] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 118.

The Johnson Automatic Sampler.[9]—This sampler designed by Paul Johnson, is described in detail under "Recent Improvements in Lead Smelting," elsewhere in this volume.

Sampling and Dry Crushing in Colorado.[10]—Under this title an important contribution to the literature of dry crushing has been made by Philip Argall, who presents data largely from his experience at the works of the Metallic Extraction Co. at Cyanide, Colo., where the fine crushing of the hard Cripple Creek ore is practiced on a large scale. Mr. Argall does not discuss coarse crushing, but advocates a reduction ratio of not more than 4:1 for any one machine. A 12×20-in. breaker, reducing to a maximum size of 1·7 in., will easily crush 25 tons per hour of ordinary quartzose ores. Talcose and wet ores cause trouble, and very wet ores should be dried before breaking.

In sampling ores containing from 10 to 15 oz. gold per ton, the following ratio between the average size of the ore cubes and the proportional weight of the sample has been found to give accurate results:—

	Diameter, in Inches.	Quantity, in Per Cent.	Pounds, in 100 Tons.
Maximum size of cubes.....	1·00	20	40,000
.....	0·25	1·25	2,500
8-mesh cubes.....	0·0925	0·0785	157
30-mesh cubes	0·0171	0·005	10

As an extra precaution in practical work, larger quantities of the finer material would be taken. In machine sampling the following important point should be noted:—

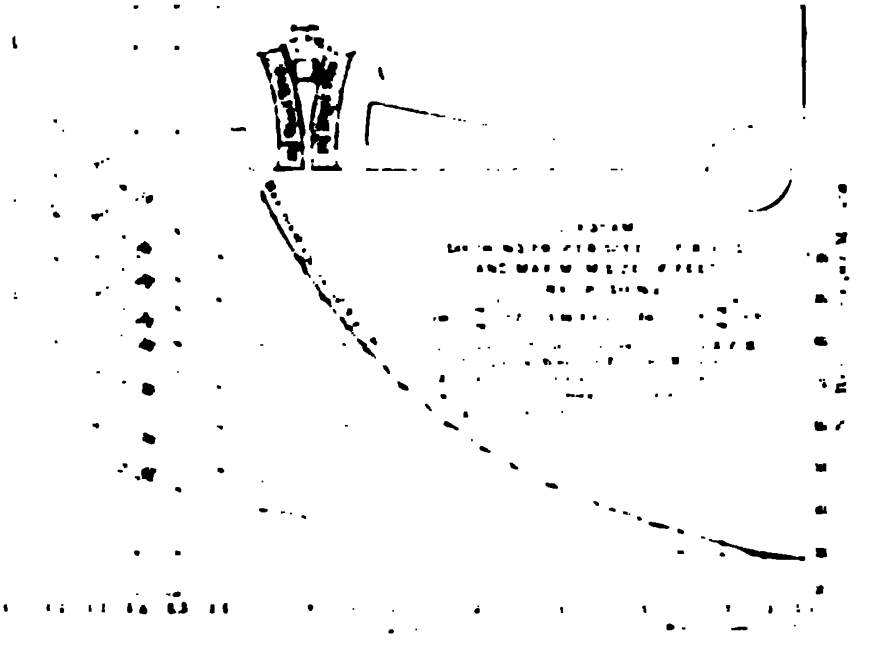
(1) Take out a sufficient quantity in the first cut to represent accurately a thorough sample at that size. (2) Always crush and thoroughly mix the ore between each cut unless it is already quite fine, and in this case the greatest possible care should be exercised to mix thoroughly before making the second cut. (3) Use riffles to reduce the size of samples after leaving the last automatic sampler. Abandon all forms of coning and quartering.

In fine crushing it is essential to reduce the moisture in the ore to about 1%, also to raise the temperature to about 250°F., more particularly if the ore is of a clayey nature; cold ores of this character lie dead on the screens, and tend to clog them; but if heated they are quite lively, and screen as well as hard, gritty ores. The efficiency of the Argall-tubular dryer is shown in the following table:—

Name and Location of Mill.	Number of Dryer	Water.		Quantity of Ore Dried per 24 Hours.	Quantity of Coal Used per 24 Hours.	Remarks.
		Before.	After.			
		%	%	Tons.	Tons.	
Bessie, Telluride, Colo.	2....	8·06	1·22	177	2·66	Coal, poor (slack); ore clayey.
Cyanide, Leadville, "	1....	10·00	1·00	70	1·00	Coal, fair; ore talcose and clayey.
Metallic, Cyanide, "	2....	4·00	1·00	.....	.....	Coal, good; ore siliceous.

The data in the above table show an average evaporative effect of 7 lb. water to 1 lb. coal; on this basis the cost of reducing the moisture from 6% to 1% will average $0·05 per ton.

[9] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 514.
[10] *Institution of Mining and Metallurgy*, Feb. 20, 1902.



percentage of finished production (Fig. 3), and the other the capacity of finished product in cubic feet per hour at given speed and sizes. (Fig. 4.)

All rolls, except those used for coarse crushing, which take the ore from the breakers, should be provided with mechanical feeders; for sizes greater than 0·25-in. the stream should not exceed in thickness the maximum faces of the cubes; below 0·25-in., however, thicker streams can be used on the principle

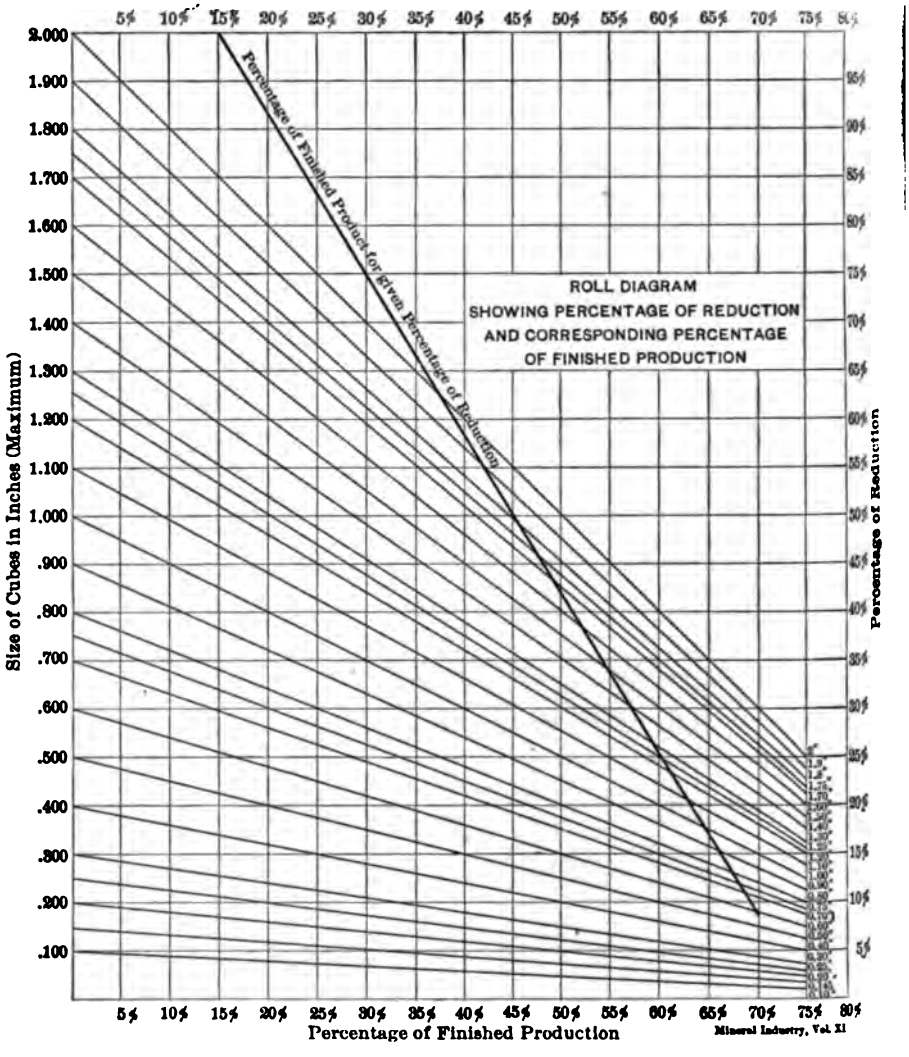
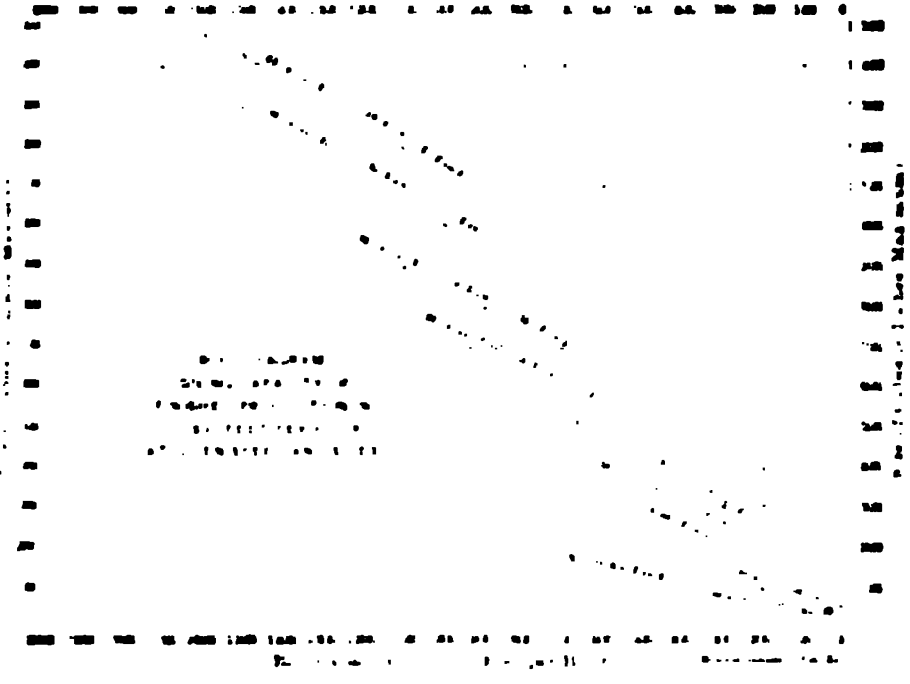

ROLL DIAGRAM
SHOWING PERCENTAGE OF REDUCTION
AND CORRESPONDING PERCENTAGE
OF FINISHED PRODUCTION
Percentage of Finished Product for given Percentage of Reduction
Size of Cubes in Inches (Maximum)
Percentage of Reduction
Percentage of Finished Production
Mineral Industry, Vol. XI

FIG. 3.—PERCENTAGE OF REDUCTION AND PRODUCTION OF ROLLS.

of "choke feed," so that the ore particles are crushed upon one another in passing the point of contact, thereby increasing the capacity of the rolls. A 26×15-in. roll at 110 r. p. m., crushing from 0·1-in. to 0·02-in. size has a theoretical capacity of only 86 cu. ft. per hour, or about 30 cu. ft. of finished product, whereas if *run* with "choke feed" on 0·25-in. size its capacity will be 75 cu. ft. per hour



which 60 cu. ft. per hour should pass 5 mesh, leaving 162 cu. ft. per hour for roll *b*, which at 90 r. p. m. will give 160 cu. ft. of product per hour passing 5-mesh screen. Adding the 60 cu. ft. already reduced to 5-mesh size gives 220 cu. ft.; of this quantity 75 cu. ft. should be reduced to 0·02 in., leaving (220—75) 145 cu. ft. for rolls *c* and *d*. In ordinary practice each finishing roll, running at 110 r. p. m., with 0·25-in. "choke feed," will furnish 75 cu. ft. per hour. The capacity of the four sets of rolls, reducing from 0·75 in. to 0·02 in. will therefore be 220 cu. ft. per hour=9·5 tons (reckoning 87 lb. per cu. ft.), which corresponds approximately to 200 tons in 21 hours. The power required will be: coarse crushing and sampling, 35 indicated H.P.; fine crushing, 50 H.P.; friction, engine and shafting, 20 H.P.; total, 105 I.H.P. The coarse crushing and sampling plant, while in operation, will require 70 I.H.P., which must be allowed for in the power provided for each unit; as the plant is operated only half of the time, the average is 35 I.H.P. In crushing 200 tons of ore to 0·02-in. size in 24 hours the work of 1 I.H.P. is 158·73 lb. per hour; in fine crushing alone it is 333 lb. per hour, data obtained from working results. The cost of sampling and crushing 400 tons per day is $0·50 per ton; not including administration, insurance, taxes, depreciation and amortization.

Notes on Sampling.[11]—The advantages claimed of the method of *"alternate shovelfuls"* over *"coning"* and *"quartering"* are: (1) greater reliability; (2) less cost; (3) rapidity; (4) economy of space, and (5) smaller capital required.

In *automatic sampling.*[11a] best results are obtained by taking the sample evenly from the whole of the stream part of the time.

The weaknesses of the *Bridgeman samplers*[12] are stated to be the lack of mixing between the apportioners; and the variability in weight of the samples obtained.

Results obtained by the *pipe* and the *single split samples* are claimed[13] to be inaccurate and unreliable.

An objection to the *old Brunton sampler*[14] is that it takes more ore from one side of the falling stream than from the other, and if a larger sample is required, a greater quantity is taken at the same intervals, and not the same quantity at shorter intervals.

The *Overstrom sampler,*[15] which operates on the same principle as the old Brunton sampler, is open to the same criticism.

The *new Brunton sampler*[16] is one of the few machines which take a correct sample. At the sampling works at Victor, Colo., the ore is crushed by a Blake breaker, set at from 1·5 to 2 in., and thence goes to sampler No. 1; this sample goes to a set of rolls 36×14 in., and thence to sampler No. 2; the sample is again crushed by 27×14-in. rolls, set to crush to 0·25 in., and thence to sampler No. 3; the sample is mixed, dried thoroughly and sent to 20×10-in. rolls, which crush to 0·0625 ($\frac{1}{16}$) in., and thence passes to sampler No. 4; each sampler takes out a sample of 20% of the ore, so that the final sample is equal to 0·2×0·2×0·2×0·2=0·0016 ($\frac{1}{625}$) part of the whole quantity sampled.

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[11] *Mining Reporter*, Vol. XLIV., Nov. 28, (1902), p. 423.
[11a] *Ibid.*, Vol. XLV., (1902), p. 99.
[12] *Ibid.*, Vol. XLV., Jan. 23, (1902), p. 119.
[13] *Ibid.*, Vol. XLV., Feb. 20, (1902), p. 206.
[14] *Mining Reporter*, Vol. XLV., March 6, (1902), p. 249.
[15] *Ibid.*, Vol. XLV., March 13, (1902), p. 272.
[16] *Ibid.*, Vol. XLV., March 27, (1902), p. 314.

tables, and slime-saving devices. The jig and table methods do not differ essentially from the general treatment of similar ores, but special work is done to save the slimes. The treatment adopted is as follows: the tailings from Nos. 1 and 2 jigs pass to a Huntington mill; the tailings of Nos. 3 and 4 jigs are treated on Wilfley tables, the middlings of which are returned to a Huntington mill; the tailings from Nos. 5 and 6 jigs, together with the product of the Huntington mills, are passed to a Sherman classifier and distributor. The coarser material from the distributor passes to four Wilfley tables and the fines to slimes settling tanks. The four Wilfley tables make a concentrate, and a generous middling product, which is re-treated on two Wilfley tables, which also make a concentrate and a middling; the middlings pass to another similar table making a concentrate and a middling, the latter being reconcentrated on the same table. There are six round, wooden slimes settling tanks about 14 ft. deep. The first is 5 ft. in diameter, and each succeeding one is slightly larger. Within each tank is an inverted cone, open at the lower end, and extending from 6 to 8 ft. into the main tank. The slimes are received at the top and pass downward through the lower end of the cone, the water rising up and overflowing from the main tank to the next one similarly built. This action creates a current in each tank, which becomes gentle in the larger tanks. The final overflow of the last tank is pumped back to the head of the mill. The slimes product of the tanks is reconcentrated over a specially regulated set of Wilfley tables, which are given an inclination toward the heads end of 0·75 in. in the whole length. The concentrates assay 27·2% lead and 58 oz. silver per ton; the tailings assay 0·2% lead and 4·8 oz. silver per ton; the table feed assays 3·4% lead and 12·5 oz. silver per ton. About 22% of the tailings which leave the mill will pass through a 200-mesh screen. The slime values saved amount to 20% of the total mill saving, thus illustrating the importance of improved slimes treatment.

Mill Practice in St. François County, Mo.[22]—A dolomitic limestone impregnated with galena and small quantities of pyrite and chalcopyrite is crushed to 4 mm. and treated direct on Bartlett tables. Formerly the product above 6 mm. was jigged, and table treatment followed, the jigs losing about 0·5% and the tables about 2% of the lead content. With the present system the loss is less and the finished product some 75% richer. The mill has a capacity of 600 tons per 24 hours using 75 Bartlett tables.

The Standard Mill,[23] *Cœur d'Alêne, Idaho.*—A canvas plant, consisting of 52 tables of 6 sq. yd. each, handles all the tailings from the Wilfleys and vanners, together with the overflow from the settling tanks. Material caught on the canvas tables is reconcentrated on two Wilfley tables. The mill greatly resembles the Helena-Frisco mill (see MINERAL INDUSTRY, Vol. X., p. 751), the principal differences in addition to the canvas plant being that the latter uses rolls for recrushing the middlings, while the former uses rolls and Huntingtons: also the Standard mill uses Wilfley tables, whereas the Helena-Frisco mill uses Frue vanners only.

[22] *Berg- und Huettenmaennische Zeitung*, Vol. LXI., (1902), p. 525. O. M. Bilharz.
[23] *American Institute of Mining Engineers*, February and May, 1902. J. R. Finley.

to (7)

tanks, 5×5 ft. by 40 ft. long. The current is very slow and the water is discharged almost perfectly clear. The thick mud is tapped at the bottom and elevated to a storage tank above the presses. It is run through the receiver into the press until the latter is full and the former nearly so. Air pressure at 90 lb. per sq. in. is then applied to force the remainder of the mud into the presses and the water through the canvas. The water leaves the presses absolutely clear. The slimes after pressing average 15% lead, 25% silver and $2 gold per ton, and contain 22% water.

The A. M. W. Mill, Leadville.[26]—The ore consists of crystals of galena, iron pyrites, and marmatite, intimately associated. The crushing is done by two Huntington mills with 40-mesh screens; 48% of the crushed material will remain on an 80-mesh screen. The ore contains approximately from 12 to 14% lead, 12 to 15% iron, 32 to 35% zinc, 5 to 8% silica, and 37 to 26% sulphur. The problem, therefore, is not one of concentration, but involves the separation of the minerals of zinc, iron and lead into commercial products. The crushed material is passed through three hydraulic classifiers, yielding coarse, medium and fine products, each being passed over 12 Wilfley tables to yield heads (lead and iron pyrites), middlings (a zinc product) and tailings. The first two products are sent to the smelter, but the attempts to treat the mill tailings have not yet been successful.

The Detroit Copper Co., Morenci, Arizona.[27]—The concentrator of this company is provided with crushers, screens, jigs, Chilian mills and various types of concentrating tables. Power is furnished by five gas engines. The ores concentrated are sulphides, 75% of the product being saved by the jigs. By means of classifiers, settlers and tables a specialty is made of the slimes. A concentration of 7:1 is claimed with 85% copper extraction yielding final tailings containing 0·8% copper.

Australian Practice.[28]—The treatment of low-grade copper ores is discussed by J. J. Muir, and attention is called to the existing conditions which have prevented profitable concentration by water. Experiments have shown that the concentration of 100 tons of an ore containing 3·94% copper yields 7·27 tons of concentrates containing 11·12% copper, and 92·723 tons of tailings carrying 3·37% copper.

Concentration Practice in Southeast Missouri.[29]—R. B. Brinsmade states that the milling cost in the best equipped concentrators is from 30 to 40c. per ton.

Practice in the Slocan District, B. C.[30]—For the concentration of silver-lead ores in this district S. S. Fowler recommends hand sorting and closer sizing than is now employed.

Ore Dressing at Santa Fé, Mexico.[31]—According to Henry F. Collins the ore from the Santa Fé mine consists of bornite and chalcopyrite, together with garnet, in a gangue of wollastonite; the copper minerals carry gold and silver,

[26] *Mining Reporter*, Vol. XLIV., Nov. 28, (1901), p. 422. A. W. Warwick.
[27] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 142.
[28] *Institution of Mining Engineers*, Vol. XXIII., p. 517.
[29] *Mines and Minerals*, Vol. XXII., (1902), p. 341.
[30] *Canadian Mining Review*, Vol. XXI., October, (1902), p. 254.
[31] *Institution of Mining and Metallurgy*, Oct. 16, 1902.

buddled slimes are re-treated, feeding by means of a "strip" to one of the round tables.

A summary of the results of the system, based on the average figures for the months of November and December, 1901, is as follows:—

	Tons of 2,240 Lb.	Metal Content.		
		Gold.	Silver.	Copper.
		Oz.	Oz.	Tons.
Ore crushed	2,670·00	420·62	10,620·25	55·73
Concentrates produced	57·48	125·80	4,049·42	26·05
Middlings produced	167·35	56·37	2,274·82	13·42
Bullion produced	.....	101·17	28·38	.....
Total metals saved	.....	283·34	6,352·62	39·47
Per cent of metals saved	.....	69·85%	59·80%	70·47%

The total cost of milling was $1·075 per 2,240 lb. of ore, not including any proportion of the general expense of administration. The tailings average from 0·6 to 0·8% copper and experiments on them with the Elmore process were unsuccessful; the only chance of further reducing the loss appears to be in a repetition of concentrations on tables and buddles.

Improvements in Lake Superior Practice.[32]—At the new Osceola Mill, Lake Superior, the Parnall-Krause circular mortars are fitted with 0·625-in. (⅝) screens, the area of which is claimed to be 11·1 times greater than those formerly in use. To clean the mortar, instead of hanging up a stamp, a valve connected with the mortar is opened, which allows the removal of the coarse copper (see under the heading "Crushing Machinery" elsewhere in this article). In this way 20% of the mineral is obtained directly. Hydraulic separators between the stamps and the jigs recover 22% more. As these products average 93 to 96% copper, about 56% of the value of the rock is obtained without jigging, and the jigs are thus relieved of the coarse copper that passes through the screens of the mortars, the losses in dressing also being reduced. In the old Osceola mill, the loss in tailings averaged 0·26%, while in the new mill the tailings during 1901 averaged 0·094%. In 1899, the percentage of extraction was a little less than 84% (see the table on p. 167 of this volume); the new mill treating the same ore and producing tailings of the above quality, would show a yield of a little more than 94%. The cost of dressing in the old mill during 1901 was 29·22c. per ton of crude ore, while in the new mill it was 22·1c. per ton.

The First Modern Ore Dressing Plant in Cornwall.[33]—This plant was erected at the Mary Ann mine, Menheniot, the capacity being 75 tons per day of 10 hours, treating tailings of an average of about 3% lead and 40 oz. silver per ton.

The equipment is as follows: Hopper feed regulator, stone breaker, picking table, shaking table, two crushing rolls, two elevators, 12 trommels, 15 jigs (four roughers), 2 three-compartment classifiers, four-compartment *spitzlutte*, two-compartment *spitzkasten*, Wilfley table and two Luhrig vanners. The plant is in two sections, with the crushing and elevating machinery between them. On the one side are 10 jigs, the first four acting as roughers; all the middlings are treated by the five jigs of the second side. The sizes of the jig screens on the first side are 10 and 8 mm., 6 and 4 mm., 4 and 3 mm., 2 mm., 1·5 mm., 1 mm., 0·5

[32] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 468.
[33] *Ibid.*, Vol. LXXIV., (1902), p. 216. W. Ryan Lewis.

Corundum Dressing.[20]

At the Robillard property, North Renfrew County, Canada, corundum rock, associated with pink feldspar and small quantities of mica and magnetite, is being milled. The process is as follows:—

(1) Mill bin, to (2).

(2) No. 2 Gates breaker, to (3).

(3) Elevator, to (4).

(4) Ore bin, to (5).

(5) One set 14×24-in. Gates rolls, to (6).

(6) Elevator, to (7).

(7) No. 1 trommel, with 5, 8, 11-mm. holes; oversize to (5); through 11 mm. on 8 mm. to (10); through 8 mm. on 5 mm. to (9); through 5 mm. to (8).

(8) No. 2 trommel with 1·5 mm. and 3-mm. holes; oversize to (11); through 3 mm. on 1·5 mm. to (12); through 1·5 mm. to (13).

(9) Hartz jig, 6·5-mm. screens; concentrates to (14); tailings to waste.

(10) Hartz jig, 9·5-mm. screens; concentrates to (14); tailings to waste.

(11) High speed jig, 4-mm. screens; concentrates to (14); tailings to waste.

(12) High speed jig, 2·5-mm. screens; concentrates to (14); tailings to waste.

(13) Classifier to remove excess of water, to slimes tank; spigot to (16).

(14) One set 30×6-in. high speed Colorado rolls, to (15).

(15) No. 3 trommel with 1 mm. and 1·5-mm. holes; oversize to (14); through 1·5-mm. on 1 mm. to (16); through 1 mm. to (17).

(16) Wilfley table; concentrates to (18); tailings to waste.

(17) Bartlett table; concentrates to (18); tailings to waste.

(18) Dryer, to (19).

(19) Magnetic separator; magnetite to waste; corundum to (20).

(20) Splitters (screens) 30, 80, 90-mesh; on 30-mesh to (23); through 30 on 80-mesh to (22); through 80 on 90-mesh to (24); through 90-mesh to (21).

(21) Graders (screens) dividing product into 90, 100, 120, 150, 180, 200-mesh, each to (24).

(22) Graders (screens) dividing product into 70, 60, 54, 46, 36, 30-mesh, each to (27).

(23) Graders (screens) dividing product into 24, 20, 16, 14, 12-mesh finished products; oversize to (14).

(24) Wilfley table; concentrates to (25); tailings to waste.

(25) Dryer, to (26).

(26) Graders (screens) dividing product into 80, 90, 100, 120, 150, 180 and 200-mesh finished products.

(27) Hooper jig; heads, finished product; tailings to waste.

Note.—Rewashing without sizing proved useless. The Hooper pneumatic jig was found to be of limited application, as the air blast is not sufficient for sizes finer than 90-mesh, and "blows through" sizes coarser than 30-mesh without

[20] *Institution of Mining Engineers*, Vol. XXIII., p. 446, and private information.

It cleans intermediate sizes successfully with the ad
and regrinding is eliminated
of ore per day, and the quantity of tailings

Magnetic Concentrators

Wetherill concentrators. These concentrators are used
under the trade name, and
Wetherill
A
110
The
Wetherill
Wetherill
A

ferrous sulphide which is susceptible to the intense effect of the magnets, while the galena and pyrite are not attracted. The capacity of the mill is from 40 to 45 tons of crude ore per day.

The Mechernich System of Magnetic Concentration.[42]—Hassreidter states that in separating blende and siderite in the Upper Harz a recovery of 98·7% of the zinc was obtained, the grains being 0·5-mm. size. With Silesian dolomitic blende of from 2 to 3-mm. size, the recovery was 91·8%, which was increased to 93·5% by reducing the size of the grains to 2 mm.

The Magnetic Separation of Zinc-Iron Sulphides.[43]—This subject is ably discussed by Guy H. Elmore.

Wenström Separators at Grängesberg, Sweden.[44]—Two of these machines treat 350 tons of magnetite ore per day, the one operating on 5 to 31-mm. size, and the other on coarser material up to about 100 mm.; the product is 200 tons of ore containing from 60 to 62% iron and from 0·7 to 0·8% phosphorus, 50 tons of fines containing from 58 to 60% iron and 0·8 to 0·9% phosphorus, and 100 tons of waste. In a few districts Monarch separators are in use.

Separating Lead, Zinc and Iron Sulphides at Rico, Colo.[45]—The ore is crushed and passed over Wilfley tables, to separate the lead and silica from the zinc and iron. The latter product is then passed through a magnetic separator to remove the iron which leaves a clean commercial product, carrying from 55 to 60% zinc. It is claimed that a sulphide carrying 20% zinc can be treated successfully, making three commercial products: a high-grade lead concentrate, an iron sulphide with practically no zinc, carrying silver, and a high-grade zinc product. The plant at Rico handles 60 tons per day, and the separated zinc ore is shipped to the Belgium spelter works. Another plant is to be installed at Leadville.

Frödings Magnetic Separator.[46]—This separator is practically a convex slime table with a series of underlying magnets extending around six-sevenths of the circumference. The magnetic particles adhere to the surface of the table, while the non-magnetic particles are washed off; the heads finally leave the table after passing the magnetic field. There are 12 magnets carrying 100 volts and 8 amperes. At Herräng a machine of this type treated 2 tons of 28% iron ore per hour, produced heads containing from 62 to 64% iron, and tailings carrying 8% iron, of which 0·5% is magnetic, the remainder being in the form of silicate. The results of concentrating unsized ore from Norberg containing 21% iron, were: heads 57% iron and tailings 6% iron.

Oil Concentration.

Experimental Results with the Elmore Process.[47]—The Elmore process of concentration of ores with oil is under experiment in London at a mill of a capacity of from 10 to 20 tons per day. A recent test on copper ore from

[42] *Journal of the Society of Chemical Industry*, Sept. 30, (1902).
[43] *Mining Reporter*, Vol. XLVI., Dec. 18, (1902), p. 504.
[44] *Berg- und Huettenmaennische Zeitung*, Vol. LXI., (1902), p. 58.
[45] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 74.
[46] *Oesterreichische Zeitschrift fuer Berg- und Huettenwesen*, Vol. L., (1902), p. 241.
[47] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 230.

colliery an Allard screen is successfully used to remove 2% of dross left in the coal after washing.

The Maurice centrifugal coal washer[51] treating coal from a mine near St. Etienne, France, gave the following results: First operation, 2,302 tons, containing 30% residue (ash and slate), yielded 1,550 tons, containing 9% residue, and 1,302 tons containing 55% residue. Second operation, 1,302 tons containing 55% residue, yielded 525 tons containing 18% residue (coal for boilers), and 777 tons of slate, containing 20% of coal.

The Craig coal washer[52] was originally designed to treat gold-bearing sands, but is now doing good work on coal up to 1·5-in. size. Before feeding to the table, the coal is thoroughly mixed with water, and allowed to fall through openings to the tables or washer. The latter is Y shaped, and the coal is fed to it at the junction of the arms where the inclination is 1 in 6 (adjustable). The table, mounted on wheels on inclined rails, is actuated by a cam, the return stroke being taken up by springs which pull it to strike against a buffer. A 5-in. stroke is used at 60 r. p. m., both stroke and revolutions are adjustable. The coal is discharged by spouts at the base of the Y and the impurities at the arms. At Coanwood colliery a washer of this type reduced the quantity of ash from 11·51 to 4·80%. Smudge containing 25% dirt has been treated with a reduction by washing to 5 per cent.

The Campbell Coal-Washing Table[53] was used on coal which passed through bars set 0·75 in. apart; the proportion of sizes being through 0·75 in. and over 0·5 in., 27%; through 0·5 in. and over 0·3125 in. ($\frac{5}{16}$), 42%; and through 0·3125 in. ($\frac{5}{8}$), 31%. A test run of 1,500 tons yielded the following results:—

	Pounds.	Per Cent.	Sulphur.	Ash.
			%	%
Raw coal	3,166,024	100	1·910	5·810
Washed coal	2,970,429	93·9	0·857	4·800
Refuse	195,595	6·1	17·617	44·996

In the Baum washer at Gelsenkirchen,[54] about 53·5 tons of coal from 0 to 80 mm. (3¼ in.) in diameter are treated per hour, two machines dealing with the 0 to 10 mm. size, and one each for the sizes, 10 to 15 mm., 15 to 30 mm., 30 to 50 mm. and 50 to 80 mm.

At Bruay and Marles, France,[55] the sizes of coal handled varies from 15 to 25 mm., and contain from 16 to 20% ash; which is reduced to 8 or 9% after washing.

The Seitz portable coal loading and screening machine[56] is operated by steam. The machine is run to the edge of a coal pile, where by means of an automatic endless-chain, belt-raking device, the material is brought to upright buckets, and thence to the screens which are placed on both sides. This machine is recommended for use in reclaiming coal from culm banks, as it would yield a saving over the machinery now in use.

[51] *American Manufacturer and Iron World*, Vol. LXX., (1902), p. 267.
[52] *Institution of Mining Engineers*, Vol. XXIII., p. 179. Wm. Scott.
[53] *Ibid.*, Vol. XXIII., p. 435. C. R. Claghorn.
[54] *Colliery Guardian*, Vol. LXXXIV., (1902), p. 1717.
[55] *Ibid.*, Vol. LXXXIV., (1902), p. 1119.
[56] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 767.

PROGRESS OF METALLOGRAPHY IN 1902

By William Campbell

the results of researches undertaken by the Committee on Alloys of the Society. Many have been already published in the Bulletin and elsewhere. The volume contains sixteen articles, including the following ones of metallographic importance: On Microscopic Metallography, H. Le Chatelier; Microscopical Study of Metallic Alloys, G. Charpy; General Method for the Microscopic Analysis of Carbon Steel, F. Osmond. The various papers are beautifully illustrated.

The Crystalline Structure of Metals.

The Crystalline Structure of Platinum has been worked out by Andrews.[1] When a small ingot of pure platinum was polished and etched with boiling aqua regia, the crystalline structure developed appears to resemble that of gold and silver. Photographs were taken, and under a magnification of 360 diameters, primary and secondary crystals are seen resembling those found in lead, iron, etc. The size of the primaries varies from 0·002 to 0·04 in., and those of the secondaries from 0·0002 to 0·007 in.

The Microscopic Effects of Stress on Platinum, by T. Andrews and C. R. Andrews,[2] show results practically the same as those of Ewing and Rosenhain, published in their paper on "The Crystalline Structure of Metals." It was found that many of the large or primary crystals had developed innumerable fine slip bands in consequence of strain, and the results confirm the observations of Ewing and others that stress alone, without etching, sometimes renders the lines of intercrystalline junction visible, providing, of course, that the stress is of sufficient intensity.

The effect of strain in altering the structure of a metal, especially a soft one, is pointed out in a note on "The Crystallization Produced in Solid Metal by Pressure," by W. Campbell.[3] In the preparation of sections of soft metals and alloys it was found that particles are apt to cling to the file, and if allowed to remain they tend to tear the surface of the metal. The effect is not immediately noticeable, but on etching the polished surface there appear besides the usual structure of the metal lines of much smaller crystals with irregular boundaries, but possessing different orientation. If the tearing effect of the file has been extreme these crystals may blot out the initial crystallization produced by the original cooling. Fig. 1 (× 80 diameters, vertical illumination shows this structure produced in cast tin and the effect has been to blot out the structure due to casting. This action occurs also when a soft metal is cut with a saw and unless the metal thus modified is removed during subsequent treatment, this crystallization appears along with the original structure on etching. Fig. 2 (× 33 diameters, oblique illumination) shows a vertical section of slowly cooled tin. The large granular structure is due to the original cooling, but in addition there appears a much finer crystallization produced by the tearing effect of the saw. This effect is only on the surface however, for on regrinding and polishing carefully the large granular structure alone remains.

[1] *Proceedings of the Royal Society of London*, 69, 433.
[2] *Ibid.*, 70; *Metallographist*, V., 286.
[3] Metallographist, V., 57.

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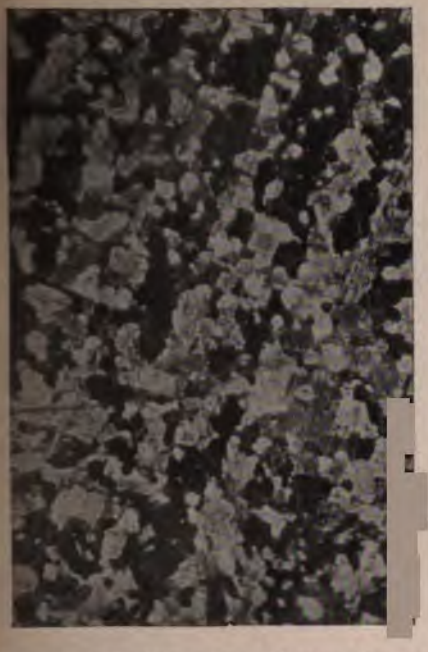

Fig. 1. (x 80 Diameters. Vertical Illumination.) Cast Tin Filed and Etched. Showing change in structure.

Fig. 2. (x 33 Diameters. Oblique Illumination.) Tin Slowly Cooled. Sawed and Etched. Showing change in structure.

Fig. 3. (x 35 Diameters. Vertical Illumination.) Dendrites on Surface of Aluminum.

Fig. 4. (x 33 Diameters. Vertical Illumination.) Dendrites on Surface of Platinum.

Fig. 5. (x 35 Diameters. Vertical Illumination.) Dendrites on Surface of Silver.

Fig. 6. (x 16 Diameters. Vertical Illumination.) Dendrites on Surface of Silver. Showing relation to crystallization.

Fig. 7. (x 30 Diameters. Oblique Illumination.) Cadmium Cast in Iron *Mold* and Etched with Nitric Acid.

Fig. 8. (x 33 Diameters. Vertical Illumination.) Dendrites on Surface of Cadmium. (Same Ingot as Fig. 7.)

in direction as they pass from one grain to another, but in one grain parallel to some one or more constant directions.

Fig. 11 (× 70 diameters, vertical illumination) shows the dendritic structure found on the base of an ingot of bismuth. It is quite distinct from that of cadmium, being apparently built up of grains or crystals, with more or less plane faces. This is what is to be expected when the strongly crystalline structure of bismuth is remembered. If bismuth be strained, slip-lines and broad bands are produced. Fig. 12 (× 33 diameters, vertical illumination) shows a strained ingot of bismuth, etched with dilute hydrochloric acid. The broad lines produced seem to resemble the twinning of a plagioclase, and it would seem probable that the bands do represent a twinning of the bismuth. For on revolving the specimen through 90° the dark parts become light and the light areas dark. In other words the black bands are those parts of the grain whose orientation has been revolved through, say 90°, just as a crystal of calcite can be twinned with a sharp blow with a knife. In lead for instance, the usual appearance is that of fine lines, hence it may be judged that lead merely slips, but does not twin.

Fig. 13 (× 30 diameters, vertical illumination) shows the dendritic structure of tin cast on stone in which the junction of three dendrites is clearly illustrated. Fig. 14 is another view of the same surface (showing a finer dendritic growth in one of the grains) after straining. Broad slip bands have been produced even more markedly than in the case of bismuth.

If zinc is examined the same structures are found. Fig. 15 (× 30 diameters, oblique illumination) shows the base of a small zinc ingot cast in stone and etched. The coarse crystallization and the twin or slip bands have been brought out. Deep etching serves to reveal the cause of the difference in orientation of crystal grains, as has been pointed out by Stead. Fig. 16 (× 33 diameters, oblique illumination) shows tin cast on stone and etched with very dilute hydrochloric acid for a considerable time. The differential etching action has laid bare the upturned plates or secondary crystals which go to form each grain and as each set is differently oriented a difference in the reflection of light is obtained.

When strain on a metal is prolonged and great, the grains tend to split up, as Prof. Ewing has shown, and a finer crystallization takes the place of the old. Fig. 17 shows the structure of cast tin which has been hammered down to about 0·02 in. thick. Annealing causes a rearrangement and the tin tends to assume a coarser structure. Fig. 18 shows the same hammered tin after annealing below 180°C. for 15 hours. The difference between the two structures is striking.

The dendritic structure of lead is apparently much finer than that of zinc, tin, etc. Fig. 19 (× 33 diameters, vertical illumination) shows the base of lead cast on stone. The crystallization is extremely small and is developed more or less along parallel axes with shorter branches at right angles. All of these parallel axes belong to the same grain or crystal, as is seen when the specimen is etched or strained, as in Fig. 20 (× 33 diameters, vertical illumination). The fine structure is composed of two series of parallel slip-lines in marked contrast with the bands developed in bismuth, cadmium, zinc, etc.

If a grain of lead is etched deeply the secondary crystals are revealed, as in the case of iron, platinum, tin, etc. Fig. 21 (× 33 diameters, vertical illumination)

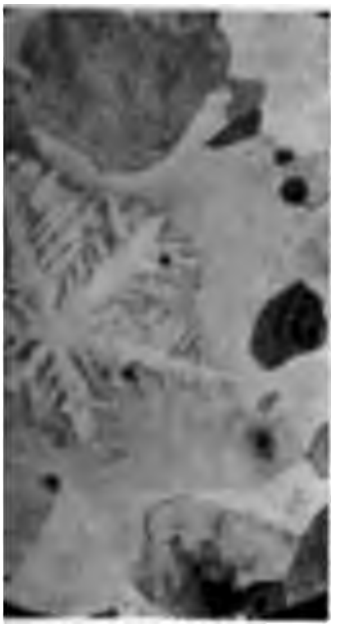

Fig. 13. (x 30 Diameters. Vertical Illumination.) Dendritic Structure of Tin Cast on Stone.

Fig. 14. (x 30 Diameters. Vertical Illumination.) Another view of Fig. 13 after straining.

Fig. 15. (x 30 Diameters. Oblique Illumination.) Base of Small Ingot of Zinc Cast on Stone.

Fig. 16. (x 33 Diameters. Oblique Illumination.) Tin Cast on Stone and Etched.

[illegible] a grain which has been etched with nitric acid. In it are seen numerous [illegible] cubes cut. These are arranged in the same direction, and it is found that on straining the specimen [illegible] sides of the tetrahedron. Further straining [illegible] series of slip-lines parallel to the [illegible] possible one is parallel to the plane [illegible] result an intimate relation between [illegible]

When zinc, tin, lead, etc. [illegible] a file hammering of tin [illegible] Annealing) shows a structure [illegible] was rolled from the bar shown [illegible] annealed and replaced by a [illegible] strip annealed at about [illegible] then etched with dilute nitric acid. [illegible]

The structure of [illegible] hammer shows [illegible] Annealed copper. [illegible]

[illegible]

[illegible] and was examined [illegible] stamped and after many [illegible] made some of the crystals [illegible] a new track was [illegible] finally followed.

[illegible]

In the *Philosophical Transactions* [illegible] thermal treatment [illegible] which consist in [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

S. A. Houghton[5] has published a large paper with numerous photomicrographs on the Internal Structure of Iron and Steel, with special reference to defective material. The photographs deal with the several kinds of material, starting with mild steel boiler plate, medium steel, high-carbon steel, cast iron, pig iron and finally spiegeleisen.

The microstructure of hardened steel has been carefully worked out by Arnold and McWilliam.[6] Three specimens of steel were taken, unsaturated, saturated and supersaturated with carbon. Their critical points were first determined and then each was quenched at varying temperatures. The paper contains numerous excellent photographs and comes to the following summary:—

1. That the clear and definite constituents of hardened steel consist of (*a*) Hardenite ($Fe_{24}C$), of which the whole mass consists only in the case of 0·89% carbon steel.

(*b*) Ferrite, Fe, which segregates more or less in unsaturated carbon steel in spite of the rapid action of quenching.

(*c*) Cementite, Fe_3C, which segregates more or less in supersaturated steels in spite of the rapid action of quenching.

The indefinite portions of hardened steels consist in unsaturated carbon steels of Hardenite containing more or less unsegregated ferrite, or in supersaturated carbon steels of hardenite containing more or less unsegregated cementite.

2. Martensite is not a constituent but a crystalline structure developed at high temperatures. It is marked in saturated carbon steels by preferential etching lines, in unsaturated carbon steels by striæ of ferrite, and in supersaturated carbon steels by striæ of cementite.

3. The existence of constituents sorbite, troostite and austenite is extremely doubtful.

The paper called forth a great deal of discussion, especially on the alleged constituents, sorbite, troostite and austenite.

In a paper on the Overheating of Mild Steel[7] by Prof. Heyn the changes of a purely physical effect unaccompanied by chemical change are discussed. The paper contains the results of many physical tests and shows that when low carbon mild steel is annealed at temperatures above 1,000°C. there occurs an increase in the degree of brittleness if the annealing period is sufficiently long. Prolonged annealing at temperatures between 700° and 890°C. produces no increase in brittleness. By suitably annealing, the brittleness of overheated low-carbon mild steels can be eliminated. If annealing is carried on at about 900°C. a short period of about half an hour is sufficient, while by annealing for several days at temperatures between 700° and 850°C. this object can be obtained.

The Effect of Reheating upon the Coarse Structure of Overheated Steel[8] has been worked out by Mr. Goransson for a steel containing 1·2% C. His experiments show that refining occurs when the steel reaches a point where all the cementite is redissolved by the martensite and this occurs where the reheating has

[5] *Institute of Marine Engineers*, April 21, 1902; *Mechanical Engineer*, IX., 617.
[6] *Journal of the Iron and Steel Institute*, 1902, I., p. 120.
[7] *Ibid.*, 1902, II., p. 73.
[8] *Jernkontorets Annaler*, LVII., p. 170; *Transactions of the American Institute of Mining Engineers*, 1902.

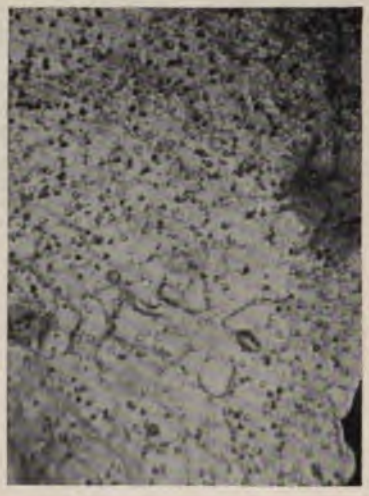

Fig. 21. (x 33 Diameters. Vertical Illumination.) Lead Etched with Nitric Acid.

Fig. 22. (x 33 Diameters. Oblique Illumination.) Strip of Cadmium Rolled to 0.075 in Thinness.

Fig. 23. (x 33 Diameters. Oblique Illumination.) Same as Fig. 22 after annealing at 180° C. for seven days.

Fig. 24. (x 33 Diameters. Oblique Illumination.) Section of Knob from Electrolytic Copper.

studied the Microstructure of Nickel Steels[12] with special reference to certain treatments.

Mathews,[13] in a paper entitled "A Comparative Study of Some Low Carbon Steel Alloys," has worked upon several alloys of iron with nickel, chromium and molybdenum. He first gives the results of testing both the annealed and unannealed specimens, then he discusses the microscopical examination with 24 photomicrographs, while the latter part of his paper is devoted to the electrical conductivity. For this work he was awarded the Carnegie gold medal by the Iron and Steel Institute.

Charpy and Grenet, in their paper on "The Equilibrium of Iron-Carbon Systems,"[14] come to the following conclusions:—

1. The separation of graphite begins at a temperature which is lower the greater the percentage of silicon.

2. The separation of graphite once begun continues at temperatures lower than those at which it begins.

3. At constant temperature the separation of graphite is effected progressively more visibly as the temperature is lowered and the amount of silicon is less.

4. The amount of combined carbon which corresponds to the equilibrium at a given temperature diminishes when the amount of silicon increases.

5. The amount of combined carbon which corresponds to the equilibrium diminishes as the temperature decreases. They studied a large number of samples of iron of varying compositions, and their results are based upon chemical analyses and microscopic examination. Several excellent microphotographs are shown.

In a paper read before the American Society for Testing Materials, Prof. Howe discusses the Constitution of Cast Iron.[15] This enlarges upon the views set forth in the *Transactions of the American Institute of Mining Engineers*, Vol. XXXI.

Prof. Arnold, writing on the "Properties of Steel Castings,"[16] states that his experiments show that pure iron and carbon steel is not suitable material for fulfilling the modern specifications drafted by engineers for steel castings. Ductility and tenacity do not accompany each other. The paper is but the first of a series to determine among other things the influence of chemical composition and of annealing as the mechanical properties and microstructures of steel castings. The paper is of great interest, for it summarizes the microstructure of material varying from 0·07 to 1·95% C.

W. M. Carr, in a paper on "The Annealing of Steel Casting,"[17] illustrates three types of steel (of same composition) by three photographs. The first, unannealed steel, shows coarse banded crystallization. The second is properly annealed steel, whose structure is very, very minute, while the third is overannealed steel, showing the coarse crystalline structure once more.

[12] *Comptes rendus*, 1903, 136, p. 502.
[13] *Journal of the Iron and Steel Institute*, 1902, I., p. 182.
[14] *Bulletin de la Société d'Encouragement*, March, 1902.
[15] *Proceedings of the American Society for Testing Materials*, II., p. 246, 1902.
[16] *Journal of the Iron and Steel Institute*, 1901, I., p. 175; *Metallographist*, V., p. 2.
[17] *Foundry*, October, 1901.

Alloys

Group B. Simple alloys of Sb_2Te_3, and tellurium having a eutectic alloy 87% tellurium melting at 421°C.

LEAD AND TELLURIUM.—Fay and Gillson[20a] have determined the cooling curves, which together with the microstructure show these alloys to be divisible into:—

A. 100 to 64% Pb. Consisting of lead-telluride (PbTe) surrounded by decreasing amounts of lead.

B. 64% Pb to pure tellurium, consisting of simple alloys of PbTe and tellurium with a eutectic point at 21·5% lead, freezing at 400°C.

LEAD, TIN AND BISMUTH.—E. S. Shepherd[21] has discussed these alloys very carefully from all sides. He gives a careful summary of the previous work, and then attacks the tenary alloys from the point of view of the phase rule, and shows that no compounds are formed, but that tin crystallizes out pure (often in an unstable denser form), whereas lead and bismuth form two series of solid solutions.

COPPER AND TIN.—An appendix to the *Reports of the Alloys Research Committee of the Institution of Mechanical Engineers,* England, has appeared, entitled the "Microscopical Examination of the Alloys of Copper and Tin." It is illustrated by 140 figures. One of the best papers as yet published on these or any other alloys is by Heycock and Neville, on the Constitution of Copper-Tin alloys.[22] In their wonderful diagram they have taken advantage of Rooseboom's theory of solid solutions, and are able to explain the whole series of alloys through all ranges of temperature and composition. Their work is based on evidence of microstructure and cooling curves, and is a monument of painstaking and care.

ALUMINUM ALLOYS.—Leon Guillet[23] has isolated a number of compounds of aluminum with iron, manganese, copper, tin, tungsten, molybdenum, etc., by heating the oxides with granulated aluminum and treating the products with acids. Brunck[24] has isolated other aluminum compounds in a similar manner. In the copper-aluminum series of alloys there are three distinct compounds according to Guillet. They are Cu_3Al, $CuAl$ and $CuAl_2$. Leverrier found Cu_3Al and Cu_3Al_2 to be the compounds at the copper end of the series, while Le Chatelier was able to separate a diffusion alloy into five distinct zones. At the top came crystallites and dendrites of aluminum in a eutectic of Al and Al_2Cu. Next came cubic crystals of Al_2Cu in the same eutectic. Below this, crystals probably of $AlCu$ are found in a ground mass of Al_2Cu. Then followed similar crystals in a eutectic alloy, whose structure can be seen under high magnification. At the base came crystals of $AlCu_3$ passing down into dendrites of copper.

The copper end of the series is very interesting, for in it is found the aluminum bronze series. It is remarkable, for there are several changes in the solid similar to those found in the copper-tin alloys and in the steels. These changes can be very simply demonstrated by means of a diffusion alloy, ranging from about 80% to 90% Cu. Two alloys, containing 80 and 90% copper respectively, were made, and the former was carefully poured onto the latter, and the whole allowed to cool.

[20a] *American Chemical Journal*, 1902, 27, p. 81.
[21] *Journal of Physical Chemistry*, 1902, 6, 519.
[22] *Proceedings of the Royal Society of London*, 1902, 69, 330.
[23] *Comptes rendus*, 132, pp. 1112 and 1333; 133, pp. 684 and 985; 134, p. 286.
[24] *Berichte*, 1901, 34, p. 2733.

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. (x 15 Diameters. Oblique Illumi-
Crystals of Electrolytic Silver.

Fig. 26. (x 15 Diameters. Oblique Illumination.) Section of Knob of Electrolytic Nickel.

. (x 35 Diameters. Vertical Illumi-
Polished Section near top of Cu-Al

Fig. 28. (x 35 Diameters. Vertical Illumination.) Same as Fig. 27 after quenching.

. (x 35 Diameters. Vertical Illumi-
Polished Section near top of Cu-Al
ilver being heated, quenched, reheated,
ly cooled.

Fig. 30. (x 200 Diameters. Vertical Illumination.) Polished section near center of Cu-Al Alloy.

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Figs. 31, 32 and 33 have been reduced to thirteen-fifteenths of original size.

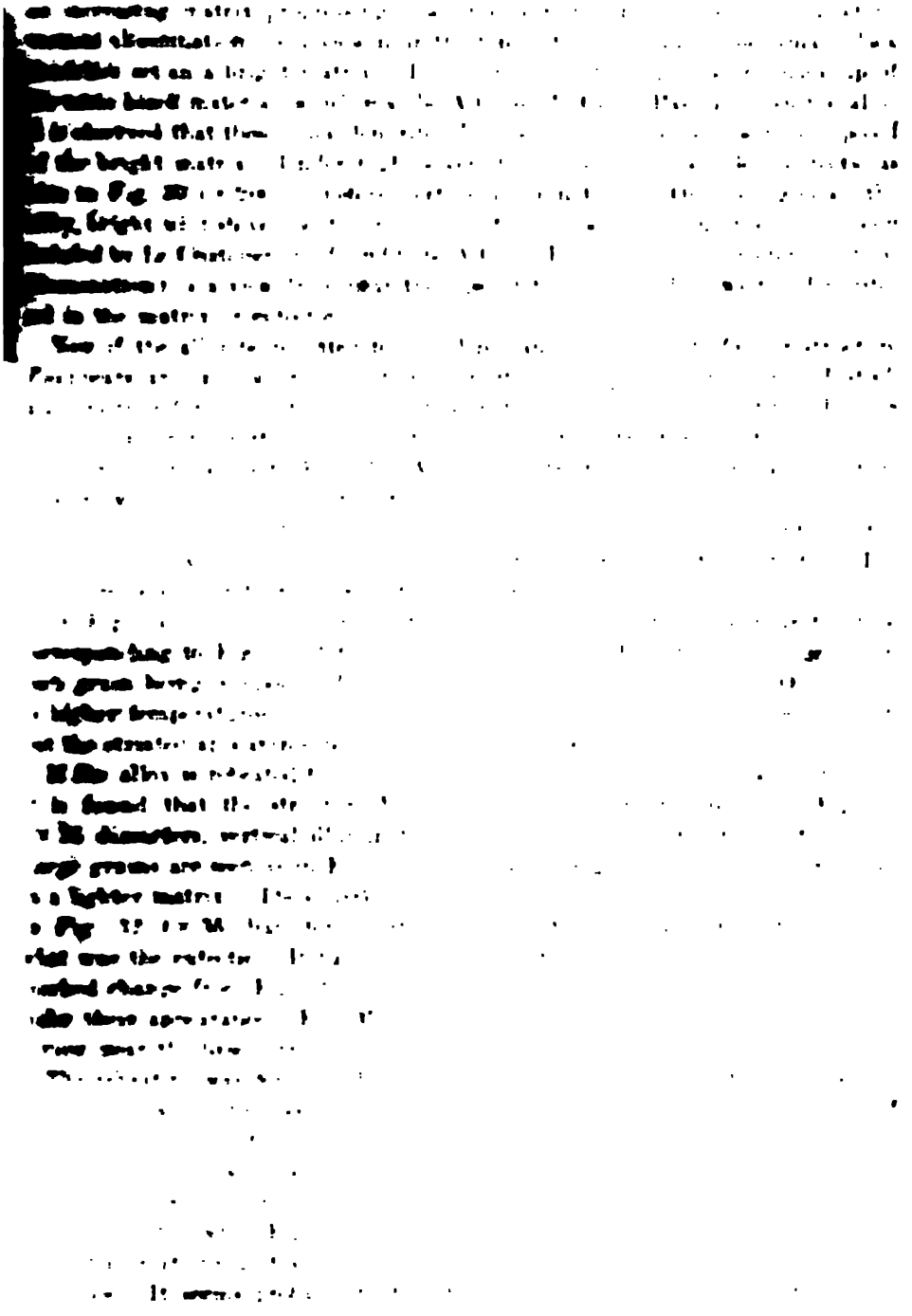
Fig. 31. (x 35 Diameters. Vertical Illumination.) Polished Section near center of Cu-Al Alloy. Shows new structure.

Fig. 32. (x 35 Diameters. Vertical Illumination.) Same treatment as Fig. 29, but lower down in Cu-Al Alloy.

Fig. 33. (x 35 Diamete Vertical Illumination.) P ished Section near base of Al Alloy. Shows dendrites

Fig. 34. (x 35 Diameters. Vertical Illumination.) Polished Section near base of Cu-Al Alloy. Shows granular structure.

Fig. 35. (x 35 Diameters. Vertical Illumination.) Polished Section near base of Cu-Al Alloy, corresponding to Figs. 33 and 34.



of copper and aluminum (between 80 and 90% Cu) exist as homogeneous solid solutions like those of the copper-tin series between 61·8 and 75% Cu, or like martensite. On cooling they rearrange themselves in the solid; when the cooling curves for this series have been worked out like those of copper and tin by Heycock and Neville and Roberts-Austen, an explanation of these changes in the solid will be obtained.

It is becoming more and more recognized that metallography and pyrometry must be used together, and the theory of solid solutions of Bakhuis Rooseboom is throwing light upon very many problems, which up to now have defied all efforts to unravel them. At last the nature of an alloy is beginning to be understood.

ALLOY STEELS.

By John Alexander Mathews

[illegible] is an alloy, and a very complex one, but the term alloy-steel has [illegible] a special significance, meaning any steel to which, in addition to iron [illegible] and the impurities common to all steel, other metals or metalloids [illegible] for the purpose of changing or improving its natural properties. Pure [illegible] cannot be classed among the "rare metals," thousands of tons of iron [illegible] of purities from a fraction of 1% upward are produced annually, [illegible] a pound of iron in its pure elemental condition has ever been made [illegible] rare smelting conditions. By "pure" we mean in a condition com- [illegible] that in which the precious metals are produced or as pure as the [illegible] copper or nickel. I have never seen more than a few grams [illegible] which might properly be called pure. The metal was made by the [illegible] A. [illegible] Roberts-Austen and used by him in his researches on the [illegible] [illegible] of iron. [illegible] was [illegible]. [illegible] of [illegible] [illegible] [illegible]

There are many who do not accept the allotropic theory; but whatever significance these critical points may have, all concede that they do occur, and that at certain critical temperatures the character of iron undergoes profound changes. Those who do not admit the allotropy of iron neither dispute the allotropy of carbon nor its occurrence in commercial iron in at least two conditions—free, as graphite, and combined, as iron carbide, and it is generally supposed that this combined carbon may exist in steel either in isolated particles or in a dissolved state. By means of these hypotheses or facts in regard to iron and carbon, we can explain many things which were but recently veiled in mystery and speculation. For this knowledge of the constitution of steel we are indebted to many of the world's ablest chemists and physicists. In the following discussion it is assumed that the reader is acquainted with the principal ideas concerning the constitution of alloys in general, and of steel in particular; but further information will be found in my article on "Alloys as Solutions," in THE MINERAL INDUSTRY, Vol. X., and in Prof. Albert Sauveur's contributions to recent volumes of this work.

Just as pure iron is a chemical curiosity, so also is an alloy containing only carbon and iron. In practice at least four other solid elements occur fortuitously in all steels, *viz.*, manganese, silicon, sulphur and phosphorus. The two elements first mentioned occurring in tenths of 1%, while sulphur and phosphorus, when present in quantities of a few hundredths of 1%, must be reckoned with in their influence upon the general properties of the steel. As yet there are no laws or generalizations relating to such complex alloys as those of six constituents; indeed little is known about ternary alloys.

In general it may be said that the influence of other elements upon iron-carbon alloys is (1) to change the temperatures of the critical points, (2) to modify the condition in which the carbon occurs, (3) to remove harmful occluded gaseous impurities, (4) to combine chemically with the iron or carbon, or both, and (5) either combined or free to form isomorphous solutions with the iron or to separate into distinct microscopic particles. In thus deporting themselves these other elements are found to improve or injure the steel; to make it harder or stronger; more ductile or more brittle; a better magnet or a better tool. The effects of these additions have been the subject of long and careful study, but the exact manner in which the added elements influence the iron-carbon system so as to produce new and useful properties in steel is not so well understood. These deeper questions are being studied by a host of able investigators, and every day new truths are discovered, which, it is hoped, will soon form a basis for rational and intelligent experimentation in revealing the hidden possibilities of the iron alloys.

In the following pages the subject will be taken up under three different heads: (1) The chemical constitution of steel alloys. (2) Some late discoveries of general theoretical interest and of practical value, and (3) the specific properties conferred upon iron-carbon alloys by other elements, considered both scientifically and practically.

THE CHEMICAL CONSTITUTION OF STEEL ALLOYS.—A number of important researches have been published recently which throw light upon the chemical

stance whose formula may be represented as $Fe_3Cr_2C_7$ (or $Fe_3C.3Cr_3C_2$). In low chromium steel, they found a carbide of composition, $3Fe_3C.Cr_2C_3$.

Tungsten combines directly with iron, forming Fe_2W, according to Behrens and Van Linge, or Fe_3W, according to Carnot and Goutal.

Molybdenum forms a compound with iron, Fe_3Mo_2, isolated by Carnot and Goutal.

Nickel forms isomorphous mixtures with iron in all proportions. Copper is dissolved in large quantities by iron without the formation of any compounds. Manganese in excess above that uniting with phosphorus and sulphur behaves like nickel; titanium in excess is believed to act similarly, but it is reasonable to expect that it would unite with both sulphur and nitrogen if they were present in the steel. Arsenic exists free in steel, and according to Stead has no bad effects upon structural steel in amounts below 0·15%. In hardened steel the arsenide of iron occurs. All commercial irons and steels contain small quantities of oxygen, hydrogen and nitrogen, and perhaps cyanides.

RECENTLY OBSERVED GENERAL PROPERTIES OF IRON ALLOYS.—*Segregation in Steel Alloys.*—Having considered briefly the chemical combinations likely to be met with in steel, it may be well to study the effects of these upon the steel as modified by heat treatment. In general the various constituents of the steels are expected to be uniformly distributed either in solution in the main mass of the iron or separate from it in minute particles microscopically discernible when the steel is suitably prepared by polishing, etching, staining or heat-tinting. When a steel is allowed to cool slowly without disturbance, the constituents may and do separate out into more or less distinctly recognizable components. When an element is added to steel in amounts beyond the solubility limit of iron for that element, eutectic alloys are likely to be found. The effects of annealing at various heats upon alloy steels have been studied by John E. Stead,[4] who, in observing the effect of such treatment upon eutectics, made a very important and extremely valuable discovery. In studying iron and phosphorus alloys, he observed that at temperatures below but near the eutectic temperature, the two constituents of the eutectic were capable of migrating. This comes as a great surprise to those who believe eutectics to be of unalterable composition. In this connection, it may be mentioned, however, that Mr. Göransson[5] discovered rings of cementite in steel "soaked" for two hours at a heat "just below Ar_1," which he thought was due to a "flow" of the cementite, although the heat was not great enough to change the laminations of pearlite. Upon further studying the migration of the constituents of eutectics, Mr. Stead found that large crystalline masses in solids have an attractive force for smaller particles of the same kind, and under suitable conditions draw the latter to themselves. If the alloy consists of the eutectic mixture, there is no tendency toward segregation; but active segregation occurs when the eutectic exists in isolated patches surrounded by large masses of one of the constituents. Under such conditions both constituents of the eutectic draw together and cease to be eutectic in character. This is true for pearlite as well as for real eutectics formed

[4] *Journal of the Society of Chemical Industry*, Vol. XXII., p. 340, 1903.
[5] The Metallographist, July, 1902, p. 216.

know in each particular case what is dissolved and what is not, and also what is the state of the substance in solution."

At the time this remark was made, Mr. Benedicks, at the University of Upsala, was bringing forth the most conclusive evidence that for small concentrations the increase in resistivity of steel is a function of the atomic weight, *i.e.*, equi-atomic solutions of metallic elements in iron produce equal increase in electrical resistance. Mr. Benedicks determined the electrical resistance of a number of samples of steel which had been carefully analyzed. They contained varying quantities of carbon, silicon, manganese, sulphur and phosphorus, the last two elements being low and fairly uniform. The steels were tested in both the hardened and annealed state. From his determinations he found that one atomic per cent. of various elements dissolved in iron produces an increase in resistance which is equal to 5·9 microhms per cm.³ He also calculated that the resistance of absolutely pure iron would be 7·6 microhms per cm.³, but this value is lower than has ever been obtained experimentally, for perfectly pure iron has not been investigated. By means of the following formula it was found possible to calculate the resistance of steel with considerable accuracy:—

$S=7{\cdot}6+26{\cdot}8\Sigma C$, in which S=resistance in microhms per cm³, and ΣC=% foreign substances calculated as equivalent quantities of carbon. In order to apply this formula it was necessary to ascertain the effect of carbon itself upon the conductivity. This Dr. Benedicks has done very skillfully. In annealed steel the carbon for the most part exists in separate particles of cementite, Fe_3C. When steel is heated to temperatures above 720°C. and suddenly cooled, this cementite disappears and the structure known as martensite results. The carbon of martensite may be combined or simply dissolved without combination. Prof. Arnold thinks that a sub-carbide, $Fe_{24}C$, exists in hardened steel. However, when hardened steel is reheated and slowly cooled, cementite again appears, accompanied by ferrite. This ferrite has usually been considered to be pure iron, and ferrite and cementite when existing in alternating bands constitute pearlite. Dr. Benedicks shows that ferrite is not free of carbon, but that annealed steels containing from 0·40 to 1·70% C, consist of cementite and iron which contains about 0·27% dissolved or hardening carbon. According to Benedicks, the carbon segregated in the free cementite exerts little influence upon the conductivity. Le Chatelier, however, gives the resistance of ferrite as 9·5 and cementite as 45.

A steel with 0·4% C or lower, if annealed or slowly cooled, shows the pearlite structure, but the ferrite in such steels contains less than 0·27% C. For example, Benedicks states that the ferrite of a 0·2% C steel would contain 0·96 to 0·07% of dissolved carbon. Benedicks' work thus confirms the chemical researches of Osmond and Werth, Carnot and Goutal, Brustlein, Arnold, and Stansfield in regard to the existence in annealed high-carbon steels of 0·27% of hardening carbon in solid solution.

All this work strengthens me in the opinion expressed repeatedly, that, in the separating or crystallizing out of the constituents of any alloy, no pure metal ever separates but metal containing more or less of the other constituents of the

carbon steel, the temperature acquired in work must not rise higher than the temperature at which the tool was tempered after hardening. Mushet, Taylor-White, and many other steels are now made which will hold a cutting edge at a temperature more than twice as high as any plain carbon steel, and this means that the speed of lathes for roughing cuts can be safely increased from one to three times the usual limit. Thallner recommends very high speed with limited depth of cut, rather than a very deep cut and low speed. The former condition is the more economical.

J. Spueller[12] has advanced a theory in regard to rapid or self-hardening steels. He says they are all alloys of iron with varying amounts of carbon, and larger, but also varying amounts of chromium, tungsten, molybdenum, titanium and boron. He omits manganese altogether, while to the best of our knowledge neither titanium or boron is as yet included in the well-known brands. He points out that these steels, when forged in the ordinary way and allowed to cool naturally, are hard, but can be both filed and drilled. When heated to from 1,100° to 1,200°C. and cooled in an air blast or quenched in a lead bath at 650°C., followed by air cooling, these steels acquire greater hardness than ordinary tempered steel, and acquire the property of working best at those temperatures at which hardening-carbon in ordinary steel passes into carbide-carbon, accompanied by softening, which renders the tool useless. In high speed alloy steels the tool can be used where the frictional heat, at the cutting edge, is from 500° to 600°C. Under these circumstances, according to Spueller, the edge becomes extremely hard, while the rest of the tool remains unchanged. He explains this by assuming that in such steels, the iron, chromium, tungsten, etc., are present as carbides, and that after the normal forging and cooling treatment, iron carbide, which is stated to be relatively soft, predominates. At the higher temperatures, however—above 1,000°C.—Spueller thinks the iron carbide is decomposed, and that then higher carbides of chromium, tungsten, etc., are formed, which then preponderate in the steel and are of sufficient hardness to produce high speed properties without resorting to water or oil hardening. Chromium carbide appears to be the most important of these hard constituents. In support of his theory Spueller states that the cutting edges of such tools behave differently toward various reagents from the other portions of the tools. He also claims to find chromium carbide in the cutting edges.

This explanation is not consistent with the fact that manufacturers of high-speed steels (1) uniformly cut down the carbon to a percentage unheard of in ordinary tool steels, and (2) that the best high speed steels contain little or no chromium. Both tungsten and molybdenum seem to impart a hardness of their own to iron, a hardness almost, if not quite, independent of the carbon contents, and a hardness not materially improved by water-quenching and which does not lose temper at a dull red heat. I do not believe that the fundamental scientific truths at the bottom of this matter have as yet been discovered.

The adoption of high speed steels in large shops has revolutionized this kind of work and has necessitated the installation of more power and heavier machinery. The contest between the makers of lathes, planers, etc., and the makers

[12] Chemiker Zeitung, 1903, Vol. XXVII., p. 105.

speed steel reminds us of that which has gone on for years between the
of armor plate and of projectiles Certain it is that shops with little
power and slowly-geared and light lathes cannot profit much by these
metallurgical achievements For roughing cuts, such as axle turning, a
to 5 times or triple the output per day formerly expected of him. High
tools are used also in wood turning, and with the same good results. A
feet per minute has been attained, working upon mild steel forgings;
with harder steel or cast iron the speed is much less, and 300 ft. is
great upon any sort of material The exhibit of the Bethlehem Steel
the Paris Exposition in 1900, attracted world wide attention to the possi-
self hardening steels for rapid work It is a pleasure to note that
work of Messrs Taylor and White has been rewarded by the be-
the Elliott Cresson Medal of the Franklin Institute for the discovery
element of a method for treating special steels which has made it pos-
increase greatly the output of machines doing roughing work. The
of steels now on the market, all of which lay claim to the possession of
cutting them to high speed work, is very large They are not all of
but at the same time it is an interesting study to compare the
these steels, and to see in how many different ways different makers
accomplish their ends The constituents are nearly as numerous and
as those of bearing or so called anti friction metals Analyses of
cannot be given here but I may state some of the limits met with in
temperature, or covered by patents Carbon, 0.1 to 2% , tungsten,
% , silicon, 0.2% to 1% chromium 0.1% to 1.5% , manganese 0.1% to 1.5% ,
from trace to 1.5% sulphur and phosphur always low Usually
elements are present in small amounts Nickel has been
added Many other elements have been
attractive as was the production of self hardening steels a year or two

Properties of Some Steel Alloys.— In the earlier part of this paper
constituents of alloy steels were briefly discussed In the concluding
of this paper is given a short discussion of the physical effects of certain
when added to steel, as well as some reference to some of the new
new properties of old alloys which interest has been awakened during
few months The alloys with some of the rarer metals will be mentioned
far as reliable information can be obtained Much work has been and remains
to be done upon alloys which have been produced in practical results, will
be considered

has proved itself to be an advantageous addition to steel for a variety
purposes Copper and the steel have entirely different densities and a homogeneous
mixture being greater than either of the constituents The
alloys to those which contain very high percentages of copper
but at the same time of which the tensile strength and elastic limit are
hardened and tempered they are found to be very well adapted for making
springs, *wire rope and springs*. In general, all the copper steels have a
tendency to weak effect upon the strength and ductility of steel, it adds the ma-

chining properties and also improves the edge-holding properties of tool-steel. When high in amount it becomes injurious to annealed steel because it tends to cause a separation of graphite, as may be noticed from the dark appearance of the fracture. From its low atomic weight it is readily seen that its effect upon the electrical conductivity of steel is very great. In low carbon materials it seems to exert a beneficial effect upon the magnetic permeability. Recently as high as 3% Si has been noted in certain high-speed steels, and Jacob Holzer & Co. (Unieux) have patented a new spring steel of the following composition: Si, 1·8 to 2·2%; C, 0·35 to 0·45%; Mn, 0·45 to 0·55%. This steel is hardened at the unusually high temperatures of between 900° and 1,000°C. Silicon raises and causes to disappear Ar_3, lowers Ar_2, and slightly raises Ar_1.

Phosphorus.—Basic open-hearth steel is found by experience to be too low in phosphorus for the successful production of sheet steel for tinning. The sheets stick together in rolling. Phosphorus prevents this trouble, and Mr. J. Stevenson, Jr.,[13] has recently patented a method for re-phosphorizing such steel, and has also patented a phospho-ferro-manganese of about the following composition: Fe, 25%; P, 15 to 25%; Mn, 50 to 60%. This is produced by using a manganiferous ore, and apatite or phosphate rock instead of a limestone flux in smelting it. The alloy is added to the metal in the ladle just as ferro-manganese is.

Regarding the general behavior of the elements iron and phosphorus, either with or without carbon, no one interested should fail to consult Mr. Stead's[14] aluable monograph upon the subject. Mr. Stead shows that the lower the phosphorus, *i.e.*, the more dilute the solid solution of phosphorus in iron, the greater the proportion of that element which will be evolved as PH_3, when the steel is dissolved in dilute hydrochloric acid. The saturation point of iron for phosphorus is 1·7%. When carbon is added to such an alloy, or one with less phosphorus, it tends to throw the iron phosphide out of solution and to increase the quantity of structurally free phosphide, Fe_3P, *i.e.*, the higher the carbon the less the proportion of dissolved phosphide; but even 3·5% C will not drive it all out of solution. The quantity of hydrogen phosphide evolved from steel decreases as the percentage of carbon increases, yet notwithstanding this, phosphorus is more embrittling in high carbon than in low carbon steel. At high temperatures both the iron phosphide and the iron carbide dissolve in the excess of iron present, but by slow cooling the iron carbide separates out at Ar_1, while the iron phosphide remains for the most part dissolved in the ferrite. Even in ordinary steels, containing less than 0·1% P, a portion of the phosphide is thrown out of solution when the carbon is above 0·9%, and the phosphide so separated may produce brittleness by forming a brittle cell structure enveloping the grains of the other constituents. Phosphorus causes to disappear the transformation point, Ar_3, when present in large amounts; this means that the grain of pure phosphorus-iron alloys is not refined at or above 900°C. as is the case with pure iron. Stead states that phosphorus aids the welding properties of iron, but that the good effects it might thus produce are more than offset by

[13] United States Patents Nos. 724,140, 724,141 and 724,142, all March 31, 1903.

[14] *Journal of the Iron and Steel Institute*, 1900, Vol. II., p. 60.

non-magnetic. In fact the usual explanation of this phenomenon is that nickel lowers Ar_1, and when Ar_1 is at a temperature below the normal temperature, the iron is supposed to be still in the condition in which it existed at a high heat, and the carbon still in the hardening condition, and hence the alloy is non-magnetic. But why is it that the magnetic property of the 25% or so of nickel does not assert itself? α-, β-, or Γ-nickel have not been heard of, but still Hopkinson found a temperature of magnetic transformation in pure nickel, much lower than that of iron. Now is it not possible that by a reciprocal action of nickel on the iron, and iron on nickel, both have their points of magnetic transformation lowered below 0°?

Guillet's results upon the microstructure of nickel steels in general show that mild steels up to 10% Ni are like plain carbon steel; between 10 to 15% Ni there is a hardening effect; from 15 to 21% Ni they are very hard because chiefly composed of martensite; beyond this amount of nickel they again become soft because martensite is replaced by Γ-iron. The higher the carbon the less nickel is required to produce these structural changes. The passage of irreversible into reversible steels corresponds almost exactly with the appearance of the crystals of Γ-iron, and the first steel in each series which exhibits this structure is practically non-magnetic.

Nickel steels melt at a lower heat than the corresponding carbon steels; there is less segregation or liquation in them and hence such steel is very suitable for castings on account of its homogeneity. There seems to be also less tendency to form blowholes. Nickel steel forgings though tough are not difficult to machine, from 3 to 3·5% Ni in a 0·25% C steel gives a tensile strength and elastic limit equal to a 0·5% C steel but still retains 25% of elongation. At the Düsseldorf Exposition a Krupp armor plate of nickel steel weighing 106 tons, and made from a single ingot of 130 tons, was exhibited. Nickel steel shafts containing up to 3·6% Ni are forged by this firm by hydraulic pressure. One of their presses is of 5,000 tons pressure.

Guillaume[16] has continued his researches upon nickel steels, and has discovered that the 36% Ni alloy expands only 0·000001 mm. per 1°C. or only one-third that of pure iron. This property has suggested its use in pendulums, measuring rods, chronometers, etc., and its non-corrosive nature makes it still more valuable for such uses. It is also adaptable to marine, boiler and general structural purposes. Theodolites, levelling instruments and other apparatus of the United States Coast and Geodetic Survey are to be made of this alloy. Another very important application of nickel steels is suggested by the anomalous expansibility of this alloy. By adding either iron or nickel to it, alloys of almost any degree of expansibility result. An alloy having the expansibility of glass may be produced to replace the use of platinum in incandescent lights. This alloy is actually in use, and it is hoped that its extended use may reserve more of the world's platinum supply for the use of laboratories, and at a lower price. Charpy and Grenel[17] have shown that an alloy containing 36·1% Ni, 0·39% C, and 0·39% Mn, not only has an extremely low coefficient of expansion, but that it is practically constant between 15 and 200°C.

[16] *American Machinist*, Jan. 8, 1903.

[17] Comptes rendus 134, pp. 540-543.

manganese steel is in some respects analogous to nickel steel. It seems to exist as in the γ condition and to form isomorphous solutions with the iron present in quantities beyond those needed to combine with the sulphur, phosphorus of the steel. Nickel (25%) gives an alloy which is practically non-magnetic, its permeability is constant at about 1.1, but when cooled it becomes powerfully magnetic and remains so when warmed up to the ordinary temperature. Hadfield's manganese steel containing 13% Mn, and 1% C has a permeability of 1.3 to 1.5 and is nearly constant for strong or weak fields. There is no appreciable residual magnetism.

Titanium seems to increase the ductility of steel and raises the elastic limit considerably. Its use is not very extensive, however. Titanium combines readily with nitrogen and thus possibly improves the quality of steel by removing from it occluded nitrogen. Howe[1] compares the effects of titanium on steels with results of Hadfield upon aluminum steel. For alloys of very nearly corresponding compositions he finds an increase of from 15 to 100% in the tensile strength, the increase being greater in proportion as the carbon increased. The tensile strength tests did not show such great differences, but still they were marked, while the contraction and elongation was always very highly in favor of the titanium steel. These effects in most cases were stated by Howe to have been due to the presence of about 0.10% Ti.

Copper and iron have recently been studied by Stead, who found that carbon steel and copper would readily alloy in all proportions. The addition of copper combines with the iron, drives the copper out of solution, and the latter will separate into layers upon slow cooling. Copper dissolves in ferrite, causing an increase in strength, with but little decrease in ductility. A combination of copper and nickel appears to be especially valuable, even a few per cent. of copper counteracting the red-shortness due to the presence of nickel. Copper also tends to prevent the formation of pearlite in steel. It has been found that steel containing 0.5% C will remain entirely ferritic after cooling from 700° C. if it contains 2% Cu, according to the researches of Hall and Wingham, while 3% Ni has no deleterious influence upon the forging properties of steel containing 0.5% C. Copper lowers the critical points but less than either nickel or manganese.

Cobalt is a constituent of steel which is frequently mentioned in foreign journals, but we never met with it in a commercial steel. It would appear from the researches of Osmond[2] that cobalt behaves like nickel in its influence upon the properties of steel. Considerable experimental work was made upon cobalt steels in Germany in order to produce the permanent magnet, however, was generally found to be inferior to tungsten steel. Cobalt steels have also been found to be very tough when quenched. The steel used contained 0.5% C, 2% Co and 1% Mn. The results of quenching the steel from various heats are given in the table on the following page.

[1] Transactions of the American Institute of Mining Engineers, vol. XXII.
[2] Comptes rendus CXI, pp. 139, 8

RESULTS OF QUENCHING BORON STEEL.

Hardening Temperature.	Tensile Strength.	Elongation.
	Tons.	%
Annealed.	29·21	11·00
800° C.	54·35	5·1
900° C.	76·20	2·7
1,100° C.	82·23	1·1
1,200° C.	58·60	0·9

A crystalline iron boride FeB, has been isolated. Specific gravity, 7·15. critical points of this steel were found at 1,140°, 1,040°, 830°, 730° and 66 The last three correspond to Ar_3, Ar_2 and Ar_1.

NOTES ON PYRITIC SMELTING.

By E. [illegible] Jr.

the heat of formation of FeO and SO_2, proves just as conclusively that a charge containing only 46·6% FeS_2, exclusive of the quantity necessary to form matte, will generate enough heat to smelt the charge without coke. In the first instance, the author erred in the comparison of the heat of formation of FeO and SO_2 with that of CO_2, by assuming that the coke was pure carbon, and was burned completely to CO_2 before the blast, giving 14,500 B.T.U. per pound of coke. The best coke has at least 5% ash, the average being about 15%, while that produced in Colorado frequently contains 25%; furthermore, in furnace practice, it is the exception rather than the rule for carbon to become oxidized to CO_2. Of course, CO_2 is formed at first, but in contact with the incandescent coke, it is reduced to CO in accordance with the reactions $CO_2+C=2CO$.

Crookes & Röhrig state: "In practice we are pretty near the truth in saying that the heat from coke (with cold blast) is that obtained by making CO; for although at the instant of its admission, CO_2 is formed, it is almost as rapidly converted into CO by the incandescent coke. But in the hot-air stove the C is converted permanently into CO_2. Burning C to CO_2 gives 13,860 B.T.U. or 3·55 times as much as by burning C to CO, which gives but 3,996 B.T.U." It is seldom that more than one-third of the available carbon in the coke undergoes complete oxidation in the blast furnace to carbon dioxide (CO_2), the remaining two-thirds forming CO. This would give for one pound of pure carbon 7,822 B.T.U., *viz.*, $\frac{1}{3}$ of 14,644 (4,882)+$\frac{2}{3}$ of 4,410 (2,940) a total of 7,822 B.T.U. (Heat of formation of CO and CO_2 given by Reychler; see below.)

The authors first mentioned above, have also erred in omitting to allow for the loss of heat necessary to expel the CO_2 from the limestone ($CaCO_3$), and the water from the charge, also that required to form slag and matte, and the quantities lost by radiation and in escaping gases. In fact, little of their work is correct save their conclusion, which has been deduced from factors in which the errors fortunately counterbalance one another.

HEAT OF FORMATION.—From McCrae's Translation of Reychler (University of Brussels), the following values for the heat of formation are obtained, which are concordant with those from the *Annuaire du Bureau des Longitudes*, also appended:—

Reaction.	McCrae's Translation of Reychler (University of Brussels).		Annuaire du Bureau des Longitudes.
	British Thermal Unit.	Kilogram Calorie.	Kilogram Calorie.
C to CO	4,410	29·40	29·00
C to CO_2	14,646	97·65	97·00
S to SO_2	3,897	69·30	71·00
Fe to FeO	2,111	65·70	66·40

In the following calculations Reychler's results are used. The weights of materials burned are gram-molecule weights, in which the number of grams taken equals the atomic weight of the element. For instance, in the calculation of the combustion of C to CO, the number of grams taken is 12, which corresponds to the atomic weight of C. The total heat produced was 29·4 calories, which corresponds to 2·45 calories for 1 g. C; or 2,450 calories for 1 kg. C; or 2,450 $\times \frac{1}{5}$=4,410 B.T.U. for 1 lb. C. Based on these figures, the heat of formation of FeO and SO_2, when pyrite (FeS_2) is burned, may be expressed as follows:—

Atomic weight of Fe	56
Atomic weight of S	32
Atomic weight of S	32
Molecular weight of FeS_2	120

one first atom of S is set free at a comparatively low temperature in the upper part of the furnace, and its heat producing value may be entirely disregarded in calculations, so that in the combustion of 120 parts of FeS_2, 56 parts of Fe and one of available S enter into the equation, these parts in percentages equal 46.7% Fe and 26.7% available S. On this basis, the heat produced by combustion of one pound of FeS_2 to FeO and SO_2 will be—

46.7% of 2,111	986 B T U
26.7% of 3,897	1,040
	2,026 B T U

1 B T U corresponds to 46% of the value of C burned to CO, or 26% of the value of C burned to CO_2, and 0.67 to CO.

Specific Heat. The specific heat, atomic heat and molecular heat of the elements in the materials charged into the furnace and the resultant furnace products being necessary for the calculation of the heat balance of a furnace, they are tabulated below:

No.	Atomic Weight	Specific Heat	Atomic Heat	Element	Atomic Weight	Specific Heat	Atomic Heat
[illegible]							

The molecular heat of a solid compound is equal to the sum of the atomic heats of the elements contained, and by dividing the molecular heat by the molecular weight the specific heat of compounds is obtained. On this basis the following specific heats of substances entering into the furnace reactions have been used:

SPECIFIC HEATS OF CHEMICAL COMPOUNDS.

Compound	Specific Heat	Compound	Specific Heat

The specific heats of the materials charged into the furnace and of the resultant furnace products are obtained by calculating the percentage of the molecular heats of the compounds entering into the composition [illegible]

Substance.	Composition.		Specific Heat of Component Parts.		Specific Heat of Substance.
Ore	FeS_2 0·45	×	0·1478	=	0·066510
	SiO_2 0·35	×	0·1798	=	0·062930
	Al_2O_3 0·20	×	0·2158	=	0·043160
	1·00				0·172600
Pyrite	FeS_2 0·90	×	0·1478	=	0·133020
	SiO_2 0·10	×	0·1798	=	0·017980
	1·00				0·151000
Coke	C 0·75	×	0·2411	=	0·180825
	SiO_2 0·18	×	0·1798	=	0·032364
	Al_2O_3 0·07	×	0·2158	=	0·015106
	1·00				0·228295
Limestone	$CaCO_3$ 0·71	×	0·1963	=	0·140798
	$MgCO_3$ 0·24	×	0·2300	=	0·055200
	SiO_2 0·05	×	0·1798	=	0·008990
	1·00				0·204988
Matte	FeS_2 0·88	×	0·1478	=	0·130064
	CuS_2 0·11	×	0·1360	=	0·014960
	SiO_2 0·01	×	0·1798	=	0·001798
	1·00				0·146817
Slag	SiO_2 0·45	×	0·1798	=	0·080685
	FeO 0·16	×	0·1368	=	0·021888
	Al_2O_3 0·10	×	0·2158	=	0·021580
	CaO 0·24	×	0·1788	=	0·042908
	MgO 0·05	×	0·2370	=	0·011850
	1·00				0·178771
Flue dust	SiO_2 0·46	×	0·1798	=	0·082708
	FeO 0·30	×	0·1368	=	0·041040
	CaO 0·08	×	0·1788	=	0·014304
	MgO 0·02	×	0·2370	=	0·004740
	S 0·07	×	0·1776	=	0·012432
	Al_2O_3 0·07	×	0·2158	=	0·015106
	1·00				0·170292

The heat units produced and consumed by the furnace using hot blast during the run of July 5, 1902, is calculated from the following factors:—

Charge.	Quantity.	Product.	Quantity.
Ore	141·00 tons.	Slag	202·50 tons.
Pyrite	15·00 tons.	Matte	16 10 tons.
Limestone	94·00 tons.	Flue dust	25·00 tons.
Coke	28·00 tons.		
Hot-air stove coal	8·20 tons.		
Temperature of air	70° F.		
Temperature of blast	770° F.		
Blast per minute	6,778 cubic feet.		

In the matter of cubic feet of air blown into the furnace per minute, no definite figures were obtainable. The blower used was supposed to pass 12,500 cu. ft. of air per minute, but was acknowledged to "slip" considerably when the pressure became high (the pressure at Golden was from 2·5 to 3 lb. per sq. in.). It did not seem from the quantity of coke consumed in the furnace, or from the quantity of coal used in the stove that this great quantity of air was passed into the furnace, or could be heated to such a degree by the small quantity of coal consumed in the stove, and steps were taken to discover the exact quantity of air *that* could be heated to a temperature 700° F. above that of the surrounding atmosphere, with 8·20 tons of coal per 24 hours. The coal used was lignite.

obtained from Trimdon Coke, the theoretical heat of combustion of which is [illegible] B T U. The data required for the calculation were as follows:

[illegible] value of coal	[illegible] B T U	Specific heat of products of combustion	[illegible]
Temperature of escaping gases	[illegible] F	Temperature of atmosphere	[illegible] F
Air required per lb. of coal	[illegible] lb.	Temperature of blast	[illegible] F
Products of combustion per lb. of coal	[illegible] lb.	Coal used per minute	[illegible] lb.
Specific heat of air	[illegible]	Cubic feet of air per pound of air at temp.	[illegible]

[illegible] under normal barometric pressure (30 in. of mercury, equaling [illegible] per sq. in.) there are [illegible] cu. ft. to 1 lb. of air, while at the altitude of [illegible] the corresponding barometric pressure (24.6 in. of mercury, equaling [illegible] per sq. in.) there are [illegible] cu. ft. to 1 lb. of air, viz. [illegible].

Full theoretical value of coal	[illegible] B T U
Losses:	
Escaping gases, [illegible] lb. at [illegible]	[illegible]
Added coal radiation	[illegible]
Total	[illegible] B T U
Practical heating value of coal per lb.	[illegible] B T U

[illegible] lb. of air heated [illegible]
[illegible] lb. of air heated [illegible]
[illegible] lb. of air heated [illegible]
[illegible] lb. of air heated [illegible] per minute

The following data of heat production and absorption are based on one minute's work of the furnace.

There are three principal sources of heat in the furnace, and nine ways in which it is [illegible] carried off, or lost:

Production	(1) [illegible] of pyrite
	(2) [illegible] of coke
	(3) Blast [illegible]
[illegible]	(1) [illegible] of CO_2 from [illegible]
	(2) Expansion of water from materials of charge
	(3) Carried off by [illegible] water
	(4) Carried off by slag
	(5) Carried off by matte
	(6) Carried off by flue dust
	(7) Carried off by escaping gases
	(8) Absorbed by decomposition of water in blast
	(9) Radiation

HEAT PRODUCTION

[illegible] of Pyrite (FeS_2) [illegible]	[illegible] charged in 24 hours	[illegible] lbs.
	[illegible] per cent. in flue dust	[illegible] lbs.
	[illegible]	[illegible] lbs.
	[illegible]	[illegible] lbs.
	Quantity [illegible] per minute	[illegible] lbs.
	Pyrite [illegible] of CO_2	[illegible]
	[illegible] charged in 24 hours	[illegible] lbs.
	[illegible] per cent. in flue dust	[illegible] lbs.
	[illegible]	[illegible] lbs.
	[illegible]	[illegible] lbs.
[illegible] Pyrite	[illegible] per minute	[illegible] lbs.
	[illegible]	[illegible]
	[illegible]	[illegible] lbs.
	[illegible]	[illegible]
	[illegible] per minute	[illegible] B T U

2. *Oxidation of Coke*	Quantity charged in 24 hours	25,000 lb.
	Moisture	1,120 lb.
		54,880 lb.
	Ash and flue dust	3,720 lb.
	Net quantity pure carbon burned	41,160 lb.
	Quantity burned per minute	29 lb.
	C burned to CO, 20 × 4,410=	88,200 lb.
	C burned to CO_2, 9 × 14,646=	131,814 lb.
		220,014 B.T.U.
3. *Heat in Blast*	Cubic feet of air per minute	6,778
	Weight of air per minute, 6,778÷16	424 lb.
	Temp. of blast above that of the atmosphere.	700° F.
	Specific heat of air	0·2377
	424×0·2377×700°=	70,546 B.T.U.
Total quantity of heat produced in furnace		426,432 B.T.U.

HEAT CONSUMPTION.

1. *Expulsion of CO_2 from limestone*	Quantity charged in 24 hours	188,000 lb.
	Blown out in fine dust	18,800 lb.
		169,200 lb.
	Moisture	3,384 lb.
	Net quantity of pure limestone	157,595 lb.
	Quantity consumed per minute	109 lb.
	109×666=	72,594 B.T.U.
2. *Expulsion of Water from Materials of Charge*	Water in ore	12,600 lb.
	Water in pyrite	1,350 lb.
	Water in limestone	3,384 lb.
	Water in coke	1,120 lb.
	Quantity charged per 24 hours	18,544 lb.
	Quantity per minute	13 lb.
	Water boils at altitude of Denver at	202° F.
	To boil from 70° F. requires	132 B. T. U.
	Latent heat of vaporization	966 B. T. U.
		1,098 B. T. U.
	13×1,098=	14,274 B. T. U.
3 *Carried Off by Jacket Water*	Quantity used per minute, 250 gallons, or.	2,084 lb.
	Temperature of inflow	70° F.
	Temperature of outflow	120° F.
	Increase of temperature	50° F.
	2,084×50=	104,200 B.T.U.
4. *Carried Off by Slag*	Quantity produced per 24 hours	405,000 lb.
	Quantity per minute	281 lb.
	Temperature of slag	2,170° F.
	Temperature of atmosphere	70° F.
	Degrees of heat lost	2,100° F.
	Specific heat of slag	0·1788
	Latent heat of fusion	90 B.T.U.
	Sensible heat, 2,100×0·1788	375 B.T.U.
		465 B.T.U.
	465×281=	130,665 B.T.U.
5. *Carried Off by Matte*	Quantity produced per 24 hours	32,200 lb.
	Quantity per minute	22 lb.
	Temperature of matte	2,170° F.
	Temperature of atmosphere	70° F.
	Degrees of heat lost	2,100° F.
	Specific heat of matte	0·1468
	Latent heat of fusion	60 B.T.U.
	Sensible heat, 2,100×0.1468	308 B.T.U.
		368 B.T.U.
	22×368=	8,096 B.T.U.
6. *Carried Off by Flue Dust*	Quantity per 24 hours	50,000 lb.
	Quantity per minute	35 lb.
	Temperature of flue dust	270° F.
	Temperature of atmosphere	70° F.
	Degrees of heat lost	200° F.
	Specific heat of flue dust	0·1701
	200°×0·1701=	34·02 B.T.U
	34·02×35=	1,191 B.T.U

Carried off by Escaping Gases	Quantity per minute	[illegible] lb.
	Temperature of gases	[illegible] F.
	Temperature of atmosphere	[illegible] F.
	Degrees of heat lost	[illegible] F.
	Specific heat of gases	0.[illegible]
	Other [illegible]	[illegible] B.T.U.
	[illegible]	[illegible] B.T.U.
Absorbed by Decomposition of Water as Steam	Quantity of water per minute	0.[illegible] lb.
	Heat to decompose and [illegible]	[illegible] B.T.U.
	[illegible]	[illegible] B.T.U.
Radiation, &c. by Balance		[illegible] B.T.U.
Total quantity of heat consumed or carried off		[illegible] B.T.U.

	Elements	B.T.U.	Per cent. of total
Producers	1. Oxidation of pyrite	[illegible]	[illegible]
	2. Oxidation of coke	[illegible]	[illegible]
	3. Heat in blast	[illegible]	[illegible]
		[illegible]	[illegible]
Furnaces	1. Evaporation of [illegible]	[illegible]	[illegible]
	2. Expansion of water	[illegible]	[illegible]
	3. Carbon dioxide	[illegible]	[illegible]
	4. Slag	[illegible]	[illegible]
	5. Matte	[illegible]	[illegible]
	6. Flue dust	[illegible]	[illegible]
	7. Escaping gases	[illegible]	[illegible]
	8. Water in blast	[illegible]	[illegible]
	9. Radiation	[illegible]	[illegible]
		[illegible]	[illegible]

When these heat units are expressed in horse power the quantity of oxygen consumed in the blast for each is also as follows:

[illegible] = [illegible] cubic feet
[illegible] horse power = [illegible] cubic feet per minute
[illegible] horse power = [illegible] cubic feet per minute

		[illegible]	[illegible]
Producers	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]
Furnaces	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]

The average engine [illegible] gives an output of [illegible] horse power for the [illegible] hours of the run, [illegible] horse power for [illegible] hours, and [illegible] horse power for [illegible] hours.

[illegible]

at which the gases escape, very little heat was obtained. One scheme for obtaining the heat from slag was to have the inlet for the blower over the forehearth, and although some degree of heat was obtained, it was detrimental to the utility of the forehearth, which should be kept as hot as possible. Another unsuccessful scheme was to run the pots filled with molten slag into a brick chamber from which the blower took the air, but difficulty is encountered when the air is heated before being taken into the blower; first, on account of the impossibility of keeping the blower properly lubricated, and secondly, on account of the decreased capacity of the blower by the air being expanded before reaching it. From the preceding figures of the operations at the Golden plant, it will be noticed that if only half of the heat of the slag could be transferred into the blast air, it would heat it to a temperature nearly equalling that obtained from the hot-air stove, and if all the heat from both slag and jacket-water could be harnessed, it would give a greater number of heat units than that produced by the burning of the coke.

A greater quantity of heat is absorbed by the decomposition of the hygroscopic water in the blast air than is generally known; and in this case it equals nearly one-half of the heat units secured from the stove. An idea of possible utility is that the air before reaching the blower might be passed over hygroscopic material, as quicklime or sulphuric acid, which would absorb the water from the air and thus save the heat otherwise necessary to decompose it in the furnace. The quantity of hygroscopic material required would be very small in comparison with the saving to be made, and especially does it seem applicable to altitudes near the sea level where the air is quite moist. The mechanical difficulty, however, of accomplishing the complete removal of water from the air would probably be great.

The expulsion of CO_2 from the limestone absorbs a great quantity of heat (666 B.T.U. per lb. $CaCO_3$), but in furnace practice this can scarcely be obviated.

[illegible]RESS IN THE MANUFACTURE AND USE OF TITANIUM AND SIMILAR ALLOYS

By A. J. Rossi

[illegible] This is the first of [illegible] articles of various compositions [illegible] The Metal Industry, Vol. IX [illegible] [illegible] [illegible]

alkali cyanides existing near the tuyeres and the titanium oxide, whereby titanium cyanonitride is formed. The latter compound, when present in pig iron is usually estimated and tabulated by chemists as metallic titanium.

The titanic pig as described can be made only in the electric furnace. It has a much lower melting point than the higher alloys, and, although containing but from 3 to 5% Ti, a mixture of from 3 to 5% in quantity gives practically the same results as with from 1 to 2% in quantity of a 10 or 12%-Ti alloy. The manufacture of this special pig does not differ materially from that of the higher alloys. Titaniferous and non-titaniferous ores are mixed in proper proportions with a sufficient quantity of carbon (in the form of fuel) to reduce iron and titanium oxides, and the mixture is then smelted; or the reduction of the titaniferous ore by carbon can be carried out in a bath of steel or iron which is so proportioned as to give the proper percentage of titanium in the final product. A 200-H.P. plant gives a daily output of about 2,500 lb. pig, or 12·5 lb. per H.P.-day.

Tests of Ferrotitanium.—The materials used in these tests were made by adding the alloy in either the cupola or the ladle, the results being nearly the same in each case. The cupola of 2,000 lb. capacity was first charged with pig iron and coke without any addition whatever, and a part of the molten iron was cast in pigs and round bars (18 in. long by 1,125 in. in diameter) or square bars (13 in. long by 1 in. square) while another portion was poured into 300-lb. ladles into which certain quantities of alloys (10 to 12% Ti) were added at the bottom. After dropping, the cupola was again charged with pig iron and coke by layers as usual with the addition in each layer of a part of the total quantity of alloy that was to be used in the charge. The alloy was added in lumps from 1 to 2 in. in size. For each mixture the cupola was charged with fresh material. The pig iron used was of two grades—No. 2 foundry coke (Warwick brand) and No. 1 best charcoal pig (Murkirk brand). The tests were made at the laboratories of Finius, Olsen & Co., of Philadelphia. With due corrections for area the results were as follows:—

	No. 2 Coke Iron ("Warwick").		No. 1 Charcoal Iron ("Murkirk").	
	Pig Smelted Alone.	Pig Smelted with 2% of Alloy.	Pig Smelted Alone.	Pig Smelted with 2% of Alloy.
	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
Tensile strength.....	24,840 25,450	27,800 28,850	28,420 27,950	31,680 30,400
Tensile strength (average).....	24,600 24,960	27,600 28,125	27,500 27,960	31,220 30,800
Transverse strength.....	.....	.....	2,960 2,872	3,112 3,250
Deflection at center of bar (12 in. between bearings).....	.....	.....	2,998 0·14	3,215 1·155

The tests show that the addition of from 0·5 to 2% in quantity of 10 to 12%-Ti alloy increased the tensile strength of the coke iron so that the average exceeded the average tensile strength of No. 1 best charcoal Scotch pig. In other words, coke iron thus treated could be substituted for the charcoal iron, which is employed to obtain certain mixtures, and at a considerable saving in cost. At the time these tests were made, the Scotch pig cost $29 per ton, while the coke iron was

at $15 and the alloy treatment cost from $3 to $4 per ton. Furthermore, the resulting iron when alloyed with titanium showed a maximum tensile strength of [illegible] per sq. in. and a maximum transverse strength of 4,250 lb., as compared to 42,500 lb. and 2,993 lb., respectively, for the same iron without treatment. These experiments have shown that 1% of alloy suffices to give these results. In some cases the improvement by treatment is still more noticeable, thus pig iron of 30,000 lb. tensile strength and 2,000 lb. transverse strength when treated gave tensile strength of from 25,000 to 26,000 lb. and a transverse strength of from 3,000 to 3,500 lb.

The quality of titanium iron has been further tested by Mr. C. V. Slocum, of the Forehaus Car Wheel Co., Pittsburg, with the following results as personally communicated to me: "For the first half of the heat and during the time no titanium was used, the highest strength observed in bars was 1,970 lb. In the last part of the heat, during which a small part of the titanium was in the charge, transverse strength ran up at once to 3,000 lb., and one bar which would evidently have run considerably over the limit of the machine was removed from it just breaking. We had bars breaking at 3,240 lb. on different days, each of which contained titanium." Mr. Slocum has also stated[1] that titanium gives fine grain to car wheels and has the effect of hardening the tread and strengthening all the parts.

New Applications of Titanium Alloys. Experiments are now being conducted with 10 to 12% Ti alloys with reference to its use in the converter. For this purpose alloys containing carbon are employed, as these serve also as a recarburizer. The oxidation of titanium in the converter tends to remove the oxygen from the steel, developing a greater heat than other metals, and thereby raising the temperature of the metal, which is frequently [illegible] The titanium alloys [illegible] great [illegible] and hardness are required in [illegible] A large manufacturer of engraving has been supplied with a quantity of titanium pig iron, which is [illegible] the material for an extensive trade. Further experiments are being made with the alloys with the view of their utilization in the manufacture of special chilled castings, such as rolls and crushers.

Metallic form of *Ferro-titanium and Silicon.* [illegible] the ordinary process in which a [illegible] high [illegible] and silicon carbide is used as a reducer of [illegible] with the [illegible] might [illegible] which [illegible] powdered [illegible] [illegible] I have made [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Ferro-titanium [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

WO_3 69·86%; SiO_2 5·04%; FeO 20·25%; metallic equivalents—W 55·20%; Fe 15·73%. After charging the furnace with the necessary quantity of aluminum in the form of ingots, scrap, etc., to reduce the iron and tungsten, the current was turned on. As soon as the oxides were introduced into the molten metal the reaction began, the iron being first reduced to a metallic state and forming a bath in which the tungsten dissolved. With the progress of the reaction, abundant fumes of alumina were given off in a dense white cloud, while the larger portion of the alumina, formed at the expense of the oxygen in the ores, constituted a sort of slag (artificial corundum) on the surface of the bath. The current was increased for a few minutes toward the end of the reaction and the metal was then cast. In one operation 646 lb. of ferrotungsten were made in thirty minutes with an expenditure of about 11 H.P. of current. The alloy had the following composition: W 75·91%, Fe 21·47%, Si 1·61%, S 0·08%, C 0·90%, Al *nil*. The percentage of tungsten in this case is nearly the maximum available from the ore. If a lower percentage is desired it may be obtained by adding scrap iron in the proper quantity to the charge.

The same process was employed for the manufacture of ferrochromium. The chrome ore supplied for this purpose was rather low-grade, and a quantity of current had to be used slightly greater than the normal to melt the slag. An analysis of the ore gave the following results: Cr_2O_3 50·29%, Fe_2O_3 16·01%, Al_2O_3 10·72%, SiO_2 4·62%, MgO 16·61%, S 0·01%, CaO 1·15%, P *nil*, H_2O 1·40%, metallic equivalents—Cr 34%, Fe 11·20%. It will be observed that 34·5% of the ore was gangue. The ore should have been concentrated to avoid loss of chromium in the slag. The ferrochromium obtained had the following composition: Cr 68·24%, Fe 26·92%, Si 1·85%, C 1%, Al 0·5%.

THE CONCENTRATION OF ORES BY OIL.*

By Warren McDermott

[illegible] attractive action of oil and grease on certain minerals has been known for [illegible] years and several attempts have been made to utilize this knowledge for the purpose of the commercial separation of valuable products. At the Du Bois [illegible] mine such a process has been successfully developed and used for [illegible] years. The application is in the form of a shaking rubber table coated with a grease [illegible] for the washing [illegible] with the result that [illegible] to prevent adhesion of the grease with the waste rock flows over [illegible] while the [illegible] retains the greased mineral particles from waste [illegible] and [illegible] was attained in small [illegible] using the [illegible] It was [illegible] and [illegible] to the [illegible] and [illegible] [illegible] and [illegible] a [illegible] was [illegible] a [illegible] and [illegible] [illegible] the oil as [illegible] [illegible] [illegible]

the distinction of an absolute discovery. Besides the ordinary American residuum, having a sp. gr. of about 0·88, similar products from other parts of the world have been found equally effective, particularly some natural thick oils from the East, with a sp. gr. of 0·80. The factor of specific gravity is of importance, because the oil when charged with particles of heavy minerals has still to float freely in water. The capacity of the oil thus to support a charge is greater than would appear possible by calculation based solely on its normal specific gravity. This is due to the agitation with the pulp which results in the oil taking up a very appreciable quantity of air, giving a certain sponginess, with naturally an increase in floating power. The properly charged oil, when examined with a glass in a thin film, is seen to be literally full of particles of mineral it has taken up; and its power of still floating appears remarkable. When overcharged with mineral, a portion of the latter settles out and sinks in water, dragging down entangled oil with it; some of this oil, freeing itself from the excess of load, will again rise in globules to the surface. The degree of viscosity is of importance as regulating the charge the oil will carry, and as affecting the mechanical loss from its influence on subdivision and re-agglomeration; but, fortunately, this degree of viscosity can be easily regulated by the addition of thinning or thickening oils or wax, and in part, if necessary, by the regulation of temperature in working. It has been discovered that the action of the oil on some ores can be stimulated (at a very nominal cost) by mixing certain acids with the oil or by the addition of a very slight quantity of acid to the pulp before the contact with oil. This increase of efficiency is in some cases—such as in the treatment of atacamite ores—sufficient to make the difference between success and failure; and is secured by the addition of quantities, which are little more than traces, of acid. Mine water of acid reaction is therefore well adapted to the process. When water is scarce it can be used over again after settling the tailings, as the suspended mud is not injurious.

2. The use of thick oil allows of its application to a thin pulp, such as that produced in wet crushing operations where an excess of water is always used. Previous efforts with other classes of oils had been unsuccessful with a thin pulp. Experiments were made with differing degrees of agitation of the oil with the flowing pulp, varying all the way from a gentle rolling over of the oil and pulp in their travel down an inclined riffled launder, to a violent agitation such as produced by passing through a centrifugal pump, or a cone mixer, or an amalgamation pan. The attempt to pass the pulp as a spray through a floating layer of oil was followed by the flowing of the pulp both over and under a fixed and a traveling surface coated with oil. In the end it was found that a slowly revolving cylinder enclosing a helical launder fitted at intervals with low baffle plates gave a sufficient agitation for most ores, and caused no unnecessary breaking up of the oil. By this means also a clean concentrate was insured, because there was no mechanical driving of particles of gangue into the oil. As a consequence of the experiments with many classes of ore under varying conditions, a standard type (or unit) of three mixing cylinders has been adopted. For some ores, requiring a very close saving of a rich mineral finely divided in the gangue, extra agitation previous to treatment in the mixing cylinders has been found effective.

eral thousand tons of ore were treated; but the mine has been closed for some time for financial reasons not connected with the process itself. A complete testing works was next erected in London with a 5-ft. Huntington mill for crushing, and an oil plant of a capacity of 25 tons per day. This plant has been running for nearly two years, making working tests on ores from various parts of the world. It is still in active operation. As a result of work done at this testing mill, in most cases under the superintendence of independent engineers, the following plants have been ordered: 75-ton plant for Norway; 50-ton plant for Lake View mine, Western Australia; 50-ton plant for Le Roi No. 2, British Columbia; 50-ton plant Tywarnhaile mine, Cornwall; 150-ton plant St. David's mine, Wales; 100-ton plant Sygun mine, Wales. Of these the last three are now in regular operation, and have been running from one to six months, respectively. The process is not at present in use in the United States, although ores from a number of American mines have been successfully tested in London, and a small hand-testing plant has been erected in the laboratory of the University of California.

At the Tywarnhaile mine a 10-stamp mill is at work with a two-unit (50 tons) oil plant, crushing old dumps of quartz and slate containing iron and copper pyrites, and assaying only 0·6% Cu. Concentrates containing 8% Cu are produced, and the results are such that the owners have decided to erect 20 more stamps with necessary oil plant for the regular mine ore. As bearing on the question of labor required for the process, it may be mentioned that one man and two boys are employed on each 8-hour shift, at wages of 75 and 37c., respectively, per day, and these hands were without skill or previous experience in mill work. The average extraction has been slightly over 80% of assay value, with a close agreement between actual and theoretical extraction. Battery screens of 20-mesh were at first employed, but as coarse as 10-mesh have since been used. Experience has shown that by reducing the agitation, and lessening the time of contact with the oil, a large percentage of the copper pyrite can be saved, while a considerable loss of iron pyrite can be allowed in the tailings, without proportionately increasing the loss of copper. As a consequence of this selective action of the oil, in aiming at the highest extraction, a higher grade concentrate can be produced for the smelters than if all mineral present were caught by the oil. Copper pyrite is particularly amenable to the oil treatment, even in the finest state of division; the rapid and complete seizure of the particles of this and some other minerals by the oil, with even a gentle agitation, having a resemblance to the operation of magnetic force.

At the Sygun mine in Wales 20 stamps of 1,050 lb. crush about 100 tons (2,000 lb.) per day through 20-mesh. The pulp passes over four Wilfley tables, and the tailings from these are treated by four units of the oil plant. For operating the oil plant portion of the mill one boy is employed at the mixers, chiefly to watch and regulate the discharge cocks of the various pointed boxes and to see that the water levels are kept fairly constant, and two hands are used on the centrifugal machines, for handling and discharging the concentrates, all on 8-hour shifts. The ore consists of slate with a little quartz, and carries both iron and copper pyrites. The average grade of the ore now being worked is about 1% Cu. The

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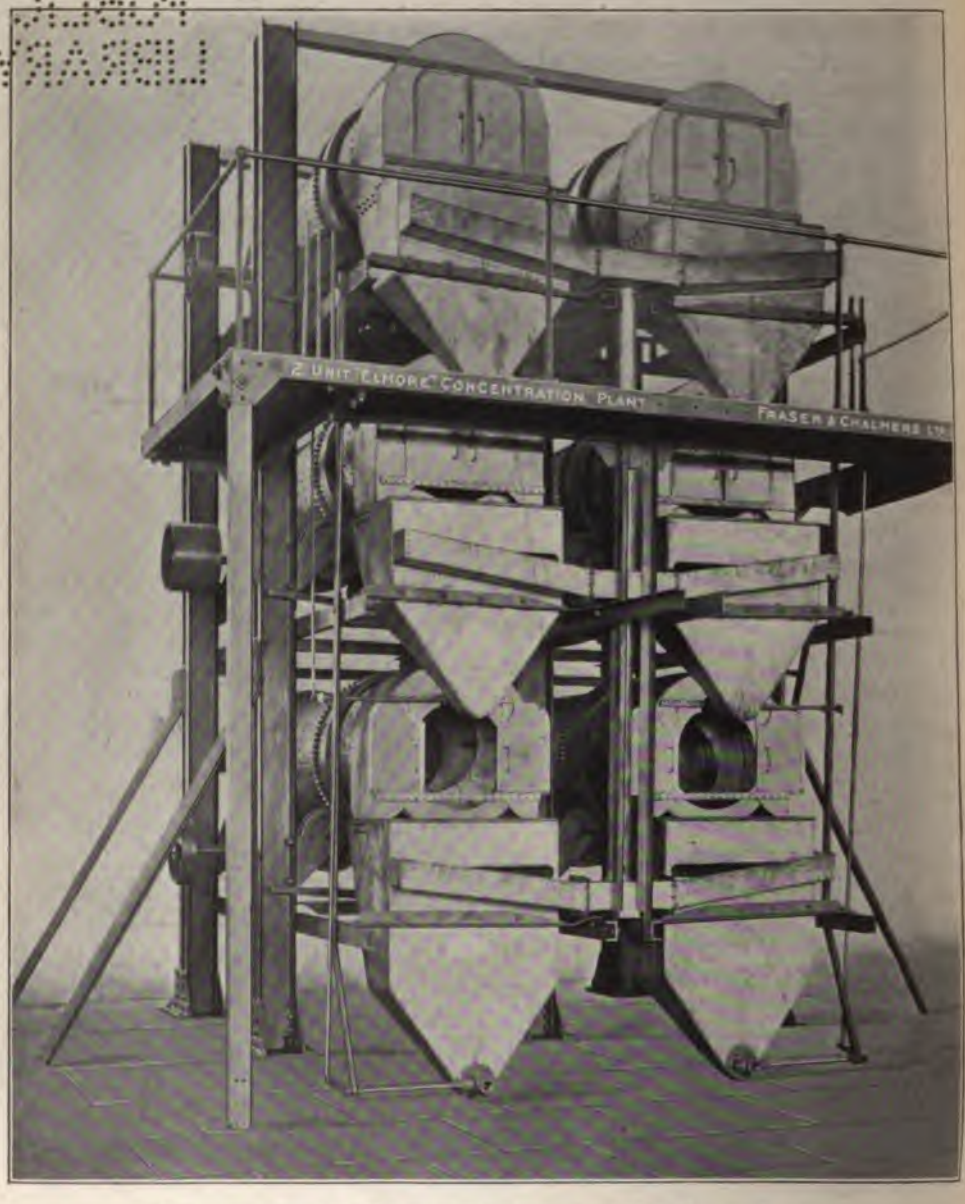


Fig. 2. Two Unit Elmore Concentrating Plant (front view).

Wilfley tables make a clean concentrate of nearly pure iron pyrite, carrying only about 3% Cu, but having an additional value, in the sulphur content, of about 50%, which allows of its sale to sulphuric acid makers, who leach out the copper from the residues, as is largely practiced in England with certain of the Spanish pyritic ores. The oil plant, following the concentrators, makes an excellent extraction in the form of a concentrate containing about 9% Cu, which is sold to the copper smelters. It has been mentioned that at the Tywarnhaile mine a partial separation of the copper from the iron pyrite is effected in the oil plant itself, by limiting the extent and time of agitation of oil with the pulp, and it is of interest to note that in the Sygun mine similar results have been established by the adoption of a system of intentionally imperfect water concentration (owing to overcrowding the Wilfley tables) as a first step, with the production of tailings relatively rich in copper pyrite on which the oil process is operated. This second method of attaining a partial separation of the two minerals has the advantage over the first of making a higher total extraction of values. The possibility of adopting either system in practice must depend on the form of distribution of the copper value in the two minerals. The mixers used in both these mills are the same and are arranged in units of three cylinders, one above the other. The cylinders are of galvanized iron and 10 ft. 6 in. long by 36 in. in diameter. They are supported horizontally on rollers and driven 6 r. p. m. by a worm gearing. Inside, a helical rib of 12-in. pitch and 6 in. high, with baffle plates at intervals, moves the stream of pulp and oil, and intermixes the same. At the discharge end of each cylinder is a pointed box, from the bottom of which the water and sand flow to the next cylinder, and from the top the charged oil overflows to the centrifugal separator. This arrangement of three cylinders allows of three separate agitations of the pulp with fresh additions of oil to insure contact with all the mineral present, and the whole operation is continuous and automatic on the flowing pulp. Figs. 1 and 2 show both back and front views of two units, and Figs. 3 and 4 show the plan and elevation of a 50-ton plant, giving the floor space and fall required. The two centrifugals shown will be the same for three or four units on most ores. The horse-power required has been carefully observed by electrical measurement of the various machines employed when in regular operation, and these powers are small. The three cylinders (or single unit mixer) require 0·7 H.P., the 48-in. centrifugal 4 H.P., the 36-in. centrifugal 2 H.P. Allowing for oil meter pumps to feed the mixers, return oil pump, and for friction of shafting, etc., the total power for a four-unit or 100-ton plant need not exceed 12 H.P., when two centrifugals are sufficient. This figure covers the extra power required during the period of acceleration of the speed of the centrifugals, when starting on new charges.

A third plant of six units has been running several months at the St. David's mine in Wales, treating the tailings of a 50-stamp gold mill, which contain a very small percentage of copper pyrite, and carry a little gold. The three mills have fully established the simplicity, efficiency and economy of the mechanical devices. The working results of the process in high percentage of extraction, in the good grade of concentrates produced, and in the small loss of oil involved, have more than equaled the estimates based on smaller suggested tests in the

London works. The loss of oil, which is one of the important questions at once occurring in a first consideration of the process, depends chiefly on the percentage of mineral in the ore, as the chief source of loss lies in the fact that the concen-

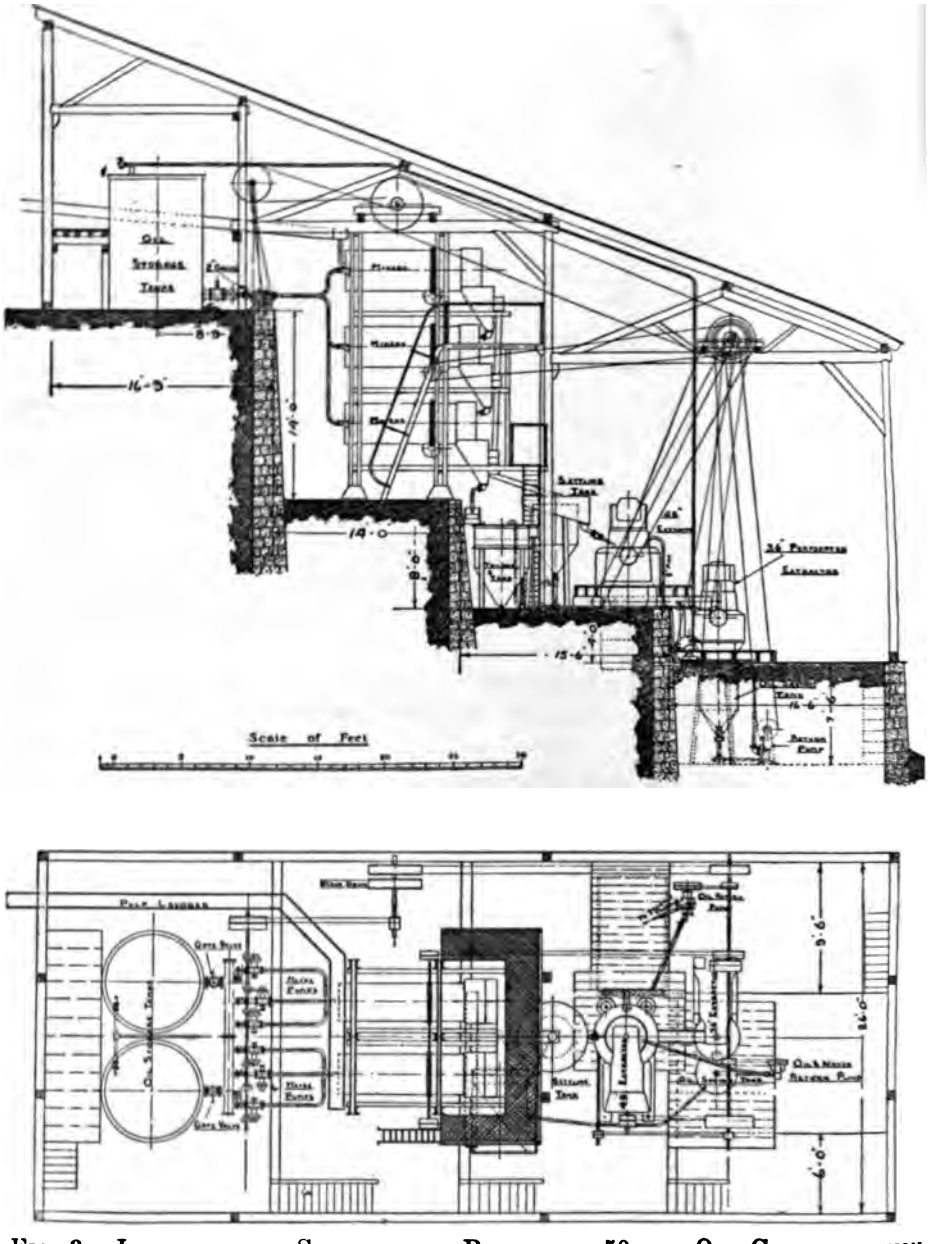
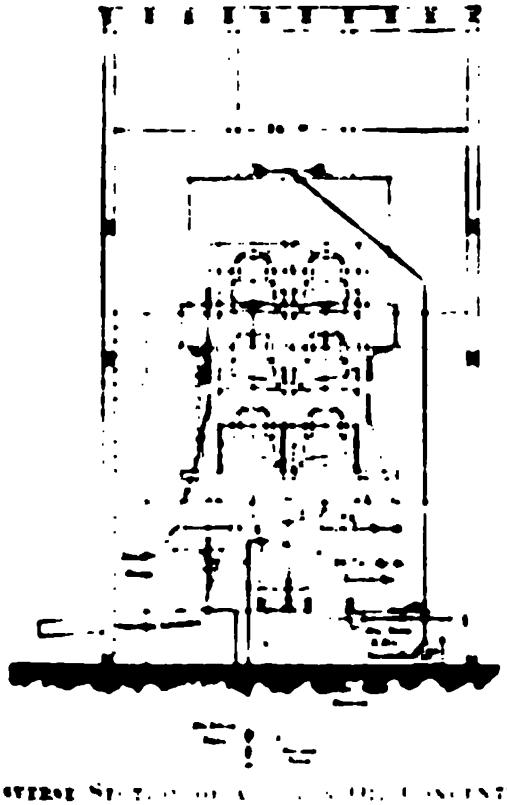


FIG. 3.—LONGITUDINAL SECTION AND PLAN OF A 50-TON OIL CONCENTRATION PLANT.

trates cannot be perfectly freed from oil. By the use of hot water, or hot air, in the second or drying centrifugal, the concentrates are at present dried down so a

from 3 to 6% of oil, or, say 8 to 15 gal to the ton (2,000 lb.) of concentrate, assuming for illustration an ore concentrating 10 to 1, and wholly by oil flotation. The use of oil would be equal to 0.8 to 1.5 gal. per ton of original ore treated. Mechanical losses in tailings, and all other sources the total loss, as stated, would be from 1 to 1.75 gal. per ton of ore. The first cost of the oil is a few cents per gallon at the refineries in the United States.

The presence of a small quantity of oil in the concentrates is not a disadvantage, as in many cases the subsequent treatment of this product will be benefited by the oil, while in the final value of the oil is worth considerably, the condition of the concentrates is advantageous for



4.—TRANSVERSE SECTION OF [illegible] CONCENTRATOR PLANT

[illegible] as shown in the [illegible] of the [illegible] of the [illegible] of oil

[illegible] advantage of [illegible] [illegible] [illegible]

In considering the possible applications of the process the following suggestions may be offered, as based on tests already made with ores from many parts of the world. 1. Treatment of float and slimes from existing concentration mills; that is, as an auxiliary to water concentration, when present losses would justify further treatment. 2. As a substitute for water concentration in the case of certain minerals, such as molybdenite, cinnabar, some brittle silver minerals and the tellurides. 3. Concentration of minerals from a heavy gangue; for example, copper pyrite, gray copper, bornite, galena, iron pyrite and other sulphides, antimonides, arsenides or tellurides of the metals from a gangue of magnetite, heavy spar, garnet, etc. 4. The separation of two valuable minerals in the same ore, as, for example, the extraction of argentiferous or auriferous sulphides and antimonides of the metals from a rock carrying tinstone, leaving the tin oxide to be washed out in a second operation. Such ores occur in South America. This process would be applicable also to the mixed copper and tin ores of Cornwall. 5. By the increased extraction of slimes and float values, the use of the oil process would remove that fear of excessive slime production, which in some cases leads to the adoption of a complicated system of gradual reduction of an ore that must be eventually crushed fine to free all the mineral, and on which ore the simple reduction by stamps would offer decided advantages, both direct and indirect. 6. The removal of the cyanide-consuming minerals of gold and silver ores before cyanide treatment. In many ores the finely divided copper-bearing minerals, most difficult to remove by any system of water concentration, cause a great consumption of cyanide, and the oil treatment does not interfere with subsequent cyanidation.

The more general of the suggestions in the above list must, of course, be taken with the necessary limitation that the mineral to be saved is of a character susceptible to oil treatment. Broadly, it may be said that the oil acts only on native metals, sulphides, antimonides, arsenides and tellurides, and not on oxides, carbonates, silicates or sulphates. There is a great difference in the activity of the oil on different sulphides. A bright metallic surface seems favorable to the most energetic action; so that while the oil will freely and instantaneously act on copper pyrite, bornite and gray copper if in an untarnished condition, there are some occurrences of copper sulphide having a more or less earthy texture, which are very little susceptible to oil treatment. Zinc blende is in most cases not well adapted to treatment; but some experiments seem to show that the activity of the extraction varies with the different lusters of blende, between the extremes of light resinous and metallic. Cinnabar, even when in a finely divided state and of somewhat dull surface, seems to be saved with facility. Galena, and various compounds of antimony or arsenic and sulphur with copper, silver and other metals, and the tellurides, generally seem to be good subjects for the oil treatment, and these are the minerals usually subject to heavy losses in water concentration. Molybdenite is picked up with great facility, and as this mineral often occurs scattered in quartz, and is not at all easy to concentrate economically, the use of oil offers in this case obvious advantages. Mention has been made of atacamite (the copper oxychloride) as amenable to treatment under certain conditions; and it is possible that there are other minerals of the oxides of the metals which may be found later to be exceptions to the general rule above mentioned. Native

lver and copper are taken up freely. Two experiments with Lake Superior ...ve been unsatisfactory, and an explanation is to be found in the fact that ...idation had occurred, shown by some of the copper being soluble in weak ...ic acid. A merely superficial oxidation of a particle of metal or mineral ...refers with the action of the oil, so that old tailings of a mill may be un... while the freshly crushed waste from the same mill will give good results. ...gards the production of clean concentrates, the results obtained with oil ...n several conditions. Taking, for example, a small particle of copper ...nd a particle of quartz, together in water and both brought in contact ...th of the proper oil, the metallic mineral at once becomes coated by the ...quartz particle is quite unaffected, it remains wet and protected from sur... ...tact with the oil by the water. A particle consisting of part quartz, part ...per is likely to be taken up by the oil from the contact effected through ...e portion. From this it follows that a degree of crushing which does ...sults free the mineral from the gangue, will lead to a lower grade of con... ...owing to the inclusion of a middle product. Excessive agitation leads ...introduction of waste rock into the thick oil by mechanical force. In most ...s possible to make a sufficiently clean mineral concentrate from the com... ...point of view. An examination under the microscope of the largest ...will show these to be mostly a middle product—part mineral, part gangue. ...gangues are more apt to enter the oil than others, but they are not those ...ost in possible mineral occurrences.

THE SAMPLING AND ESTIMATION OF ORE IN A MINE.

By T. A. Rickard.

Introductory.—It is held by some that to publish the details of personal practice is unprofessional. Others are of the opinion that while it may be well for professional men to discuss with freedom, but among themselves, the methods they employ in their work, it is poor policy to take the public into their confidence. As regards the first, no defense should be necessary in the face of the recent growth of technical associations which are founded for the avowed purpose of disseminating the knowledge acquired by their members; while, as to the second objection, it suffices to say that the mining engineer suffers from the ignorance of the public no less than the public itself, and, therefore, every step which will promote a better understanding between them is bound to be to the interest of both.

Other considerations, equally strong, prompt the willing distribution of the little knowledge which any individual among us may happen to possess. To give is to receive. No man realizes the limitations of his knowledge until he begins to crystallize it into writing, and if he be moved by a fraternal spirit to give a few hints to those who are his juniors, he will find that the effort will teach him more perhaps than those he has set out to help. It was well said by a man of wide learning that the best way to find out all about a subject was to write a book upon it.

There was a time when the examination of a mine implied merely a perfunctory visit to the underground workings, the copying of maps and the tabulation of the output. On this flimsy foundation it was considered proper to base an estimation of values. Other times, other methods. During later years the common sense of every-day business has been introduced into the industry of mining, and it has become the practice to investigate with a thoroughness quite unknown twenty years ago. That we owe this betterment to the Rand is likely, for, while those of us who have found an adequate field of activity elsewhere have improved *our own* methods without conscious suggestions from the outside, it is probable *that* the very atmosphere of thought breathed by the earnest men of the pro-

been unusually small in comparison to that which is required to keep step with the stoping operations; furthermore, in milling it is not uncommonly found that the power used during a part of the year is derived from water, which is either free of cost or relatively cheap, and that during the remainder of the year coal or wood has to be consumed, to generate steam, at a much greater expense. These are some of the errors against which one has to be on guard. Speaking broadly, the safest way to avoid them is to quote costs covering a period long enough to include the vicissitudes of seasons and markets.

Mines are rarely in a stationary state of development; like man himself, they are either growing or declining. When an engineer examines a mine he obtains data which are representative of conditions liable to change on account of the probable expansion or contraction of the entire enterprise; therefore, the figures he gets are apt to represent a passing phase in the development of the particular undertaking, and he cannot arrive at the average costs for the future by simply dividing the expenditure for a given period by the tonnage mined during that period. If the property is a steady-going concern, which has been operated for many years under conditions which are likely to continue unchanged, then indeed he has an easy task, and, given correct figures, he has only to perform a plain sum in simple division. Such cases are rare. Mines are usually bought by capitalists because they think they can enlarge the scheme of operations so as to make the business more profitable than has been the case under the previous ownership. This often entails a sweeping change in the manner of carrying on the enterprise; the entire business is conducted on broader lines, and it is assumed that a larger scale of operation will result finally in a considerable diminution in the average cost per ton. Apart from the fundamental supposition of ore-reserves big enough to warrant this expansion, there arises the question whether the money to be spent in extra equipment, a better trained staff, more vigorous and extensive development of the mine, etc., will result in a reduction in costs to the extent estimated. Experience has shown that sanguine expectations in this regard are not always fulfilled, and that a single mine owner or a small local syndicate can often, in spite of imperfections of administration and equipment, work a mine at a cost per ton which will compare favorably with that of a big company having the large permanent expenditures inseparable from the very nature of its organization. In judging of this, experience is the only guide, no rules can be laid down, and each case must be considered apart and on its own merits.

In the case of an undeveloped mine, in a new district, reliable data concerning costs are not available. Under such circumstances it is well to supplement one's judgment by visiting the nearest mines which are being operated under like conditions. To those devoid of experience the situation is honeycombed with pitfalls Western Australia afforded many lamentable examples of this during the years between 1895 and 1898. The majority of reports made at that time omitted to include any estimate of costs, all the available space being taken up by flamboyant statements of results obtained from rough sampling, together with wild prophecies concerning enrichment in depth based upon the presence of sulphides, tellurides, etc. It is a fact that many reports, which confessed to an average of 8 or 10 dwt. gold per ton of ore, advocated the purchase of mines situated in localities

not be lightly undertaken. It should always be preceded by a preliminary investigation. In going through the mine for the first time the engineer will observe that either the present value of it or, perhaps, its future prospects, hinge upon certain facts; it may be a question whether the lower workings exhibit a falling off in value, it may be important to ascertain whether particular ends of levels or particular stopes are really as good as represented. A few samples will throw light on these points, and, if these are satisfactory, then it will be well to test certain portions of the mine more thoroughly, and in this way finally get data which will determine whether a complete sampling of all the workings is justified.

In organizing the sampling gang it is necessary to adopt a system in order to avoid confusion. If it is a small mine, or if the conditions render it advisable to keep quite clear of any assistance from the management, then the engineer will employ only his personal assistants, and, whatever their number, he will divide them into pairs, one of whom will break the sample while the other holds the box to receive it as broken. If, on the other hand, the examination is being made for the owner of the mine, or the conditions otherwise warrant the engineer in accepting the good offices of the management, so that he can utilize the services of workmen on the property, then the task is easier and he can put each of his assistants to work with a miner, the latter doing the muscular work of breaking the ore while the assistant watches to see that the sample is fairly taken, and collects it as it falls into the box or other suitable receptacle made for this purpose.

Next, it is necessary to determine what interval to allow between samples. If the ore is fairly regular in width and value, an interval of 10 ft. will usually suffice; if it is very spotty in value and subject to sudden changes in width, a lesser interval will be required. I have been compelled to sample every 3 ft. in the case of a vein, the ore of which varied between 1 in. and 1 ft., with an assay content ranging between 10 oz. and 1,000 oz. silver. In such a case extreme care to sample accurately at very short intervals is absolutely imperative in order to get at any kind of idea regarding the average value of the ore. When a lode is built up of the common sulphides, such as pyrite or galena, the variations in value are apt to be small, and under such conditions 20 ft. may not be unsafe. Even though you may decide to take samples at much smaller intervals, it is best to start off with a large interval, say, of 20 ft., and when the assay returns are received you can cut this down by taking intermediate samples, if the circumstances warrant it. This will prevent useless labor over stretches of poor ground, and at the same time suggest the proper interval required wherever the workings are in good ore. Having settled this point, the next step is to take the first assistant and measure as regularly as possible along the workings, marking each successive place with colored chalk so that there can be no mistake as to the point where the sample is to be taken. Then one of the assistants or the engineer himself, at all events, a man who has had some training as a mine surveyor, is told off to make sketches of the workings as the sampling proceeds, noting the variations in the vein, the number of each sample and its position, and gathering other information, often extremely important, such as develops in the course of the work done by the sampling gang. Another man sees to the correct labeling of the samples, the sacking and sealing, and the removal of them to a safe place. All the data thus obtained should be set down

ples across a vein 12 ft. in cross-section, and in accomplishing this they dulled 35 moils. This example was one of good, honest sampling work.

The Size of the Sample.—This question is an important one, and it is a matter to be decided by convenience, scientific principle and experience. Considering the least important first; large samples are more difficult to handle than small ones and require more assistance. In mountainous regions or in desert places, where facilities for crushing the ore are lacking, it will be found inconvenient to break samples so big that their reduction by hand consumes much time. Occasionally greater inconvenience than this will arise through the want of facilities for removing the ore from the mine without entrusting it to unsafe hands. The factor of time has been mentioned, that of cost must not be forgotten, for time and money are valuable alike to the engineer and to his client, so that the former will find it advisable to "cut the coat according to the cloth." Every engineer meets obstacles such as have been referred to, and these vary so much with each individual case that it is needless to attempt to specify them in greater detail.

The size of the sample will also depend upon the facility with which the ore can be broken, because the scientific principle underlying the act of sampling is the obtaining of a true cross-section of the lode. In the case of an ore having the consistency of cheese, which is by no means an impossible occurrence and is approached by certain lodes which are built up of crushed material, a perfect sample can be obtained by running a scraper over it so as to make a narrow furrow across the full width of it. This will result in a sample of minimum size. On the other hand, in order to obtain a true sample of a large lode made up of streaks of varying hardness and uneven fracture it will be found necessary to break a hundred pounds at the very least. In such a case it is impracticable to secure a sample of the hardest portions except in large irregular pieces, and this necessitates the breaking of a proportionate amount of material from those places where the ore is much softer or of easier fracture. In hard quartz-veins it will be found that a channeling from 4 to 6 in. in width, and from 0·5 to 1 in. deep, will be adapted to the securing of a true sample; in those instances where the ore has a fairly even grain, as with replacement deposits in igneous rocks of granular texture, it will be found that a groove 3 in. wide, and from 0·25 to 0·75 in. deep, will give a true sample. The minimum size of groove which will yield a correct result should be chosen because any unnecessarily large groove simply increases all the work of subsequent reduction and handling of the samples without a commensurate increase of accuracy in the final results. Furthermore, one has always to remember that two samples of 50 lb. each at 5 ft. apart are better than one sample of 100 lb. at an interval of 10 ft. The whole idea underlying the operation is that of securing an average, and it is obvious that the larger the number of data, the more likely one is to approximate the truth.

The next factor is more important than the two already considered. I refer to that invaluable guide, experience, without which all work of this kind is as dangerous as is mountaineering in the Alps to a thoughtless tenderfoot. To one who has done his own sampling and assaying there has often arisen the inevitable contrast between the dimensions of the sample and those of the gold button which represents its contents. Whatever the size of the original sample,

of paper, detached from a notebook, but in this form it is apt to get torn or the number upon it obscured, especially when the ore is moist, therefore it is best to use a metal or wooden tag especially prepared for this purpose. The latter will be found convenient. Get a lot of small pieces of soft wood (0·125 in. thick, 1 in. wide and 1 5 in. long), and mark the numbers of the samples upon them by the use of a hard pencil; this will remain as a visible indentation even after the pencil trace has been rubbed off.

The samples are then removed to a safe place, either temporarily in the mine itself or to a building where they can be locked up. Then comes the work of reducing them in bulk by crushing and subdivision. If an assay office is conveniently at the engineer's disposal he will probably find a rock-breaker which he can use, otherwise a portable rock-breaker, worked by hand, will be found a useful machine to take with him when a large sampling job is to be done. In the absence of these conveniences the ore is broken by hand with a cobbing hammer, to the size of walnuts, and then subdivided. This is followed by further reduction in size and subsequent subdivision by quartering.

It is usual to place the crushed ore upon a square sheet of canvas, which is rolled backward and forward in opposite directions in such a manner as to mix the ore lying upon it, until finally a conical pile is left standing in the center. This is flattened to a frustrum previous to quartering, the two opposite quarters being taken and again mixed previous to a further mixing and quartering, until the bulk of the sample has been reduced to the size considered suitable for shipment to the assay office.

The foregoing method is open to criticism. In the first place, the rolling canvas is not nearly so good a way of mixing as it looks, the fines are apt to slide over the surface of the canvas instead of becoming thoroughly mingled with the coarser particles; moreover, the cone which is finally formed is deceptive in that the fines are likely to be collected not at the center of the base of the cone, as is supposed, but to one side so that, in quartering, any particular division may include an undue proportion of the fines, which usually form the richest part of the sample. Further, in flattening the cone into a frustrum, for convenience in quartering, it is difficult to distribute the ore evenly, and though great care be taken to draw the ore in a straight line outward, toward the circumference, the distribution is liable to be faulty and this part of the work may be so imperfectly done as to become a source of error.

An alternative, and better, method can be suggested. Get a few short boards, or cause some to be sawed to the required length, of about 6 ft., and put them together so that they will make a platform which can be kept firmly in place by being spread upon a couple of sills and wedged in with stones. Then, if the joints are not tight, put your sheet of canvas upon it, not to roll the samples within it, but merely to prevent any leakage of fines through the cracks between the boards. When the sample is crushed, gather it up, with a scoop or other handy implement, to the center, lifting the broken ore, shovelful by shovelful, and pouring it as nearly as possible at the same central point so as to aid the mixing of it. In doing this it will be found convenient to use the "cone," in vogue at many smelters,

thing better than mere mule-like persistence to overcome them, and the men who can do a difficult piece of sampling honestly and well, can be entrusted to do work for which much greater credit is usually given by those in authority.

Precautions in Sampling.—Although the greater thoroughness with which mines are investigated at the present time has made trickery scarce, instances of the latter do occur occasionally. They are rarely exposed because of the lack of evidence, and, therefore, the occurrence of them is obscured amid those failures and disappointments in mining which arise from other causes. The tampering with samples, called "salting," and the blocking up of workings which might give unfavorable testimony regarding the condition of a mine are two possibilities against which one must be continually on guard. To prevent "salting" it is imperative that the work be done by trustworthy assistants and in the case of a large mine where it becomes necessary to employ workmen whose antecedents are unknown, it is well to arrange that the work be done in pairs, the miner breaking the samples under the direction of an assistant who holds the box to catch the sample as it is broken. When the sampling is done it is well for the chief himself to take a certain number of samples, aided by his first assistant, these samples being taken not at haphazard but in such a way as to check the previous work. One of the best guards against any successful tampering with one's samples is to take an occasional sample of waste. If the samples are all salted the assay of the waste will disclose the fact. Occasionally it may be well to fill one or two sacks with material the exact assay contents of which have been previously determined. In any event it is better not to use sacks which are numbered or otherwise marked on the outside, because, should trickery be purposed, such marks make it easy to note from what parts of the mine the various samples come, and to salt them accordingly. It is well to assay the samples on the spot, if a suitable assay office is available, particularly when the engineer, or one of his assistants, is a good assayer, as is frequently the case. Of course, in using a strange assay plant it is necessary to guard against fraud, and to this end it is well to test the fluxes used, by assaying a charge without ore every time a batch of samples is put through the furnace.

During the interval which elapses between the time when the sample is first broken in the mine and its final assay, it is necessary that the sack containing it should be sealed. It is a good thing to use uncommon wax and an uncommon seal so as to render trickery more difficulty. It is well even to use a peculiar kind of string for tying up the sacks. "He is most free from danger who, even when safe, is on his guard." Any extra precaution should never be considered a nuisance; on the contrary, it ought to become a habit. Cases of salting have been known where the ore has been artificially enriched without breaking the seal and without puncturing the sack, and I know of an instance in which samples of copper ore, put into a carpet bag, were withdrawn and substituted with others by removing the bottom of the bag and sewing it up while the engineer was asleep. "Dead things will crawl." "Eternal vigilance is the price of safety."

Unfortunate consequences have sometimes ensued from the failure of an engineer to see all the workings of a mine. This may be due either to carelessness or oversight, but it may also be due to the rascality of the mine owner. Cross-

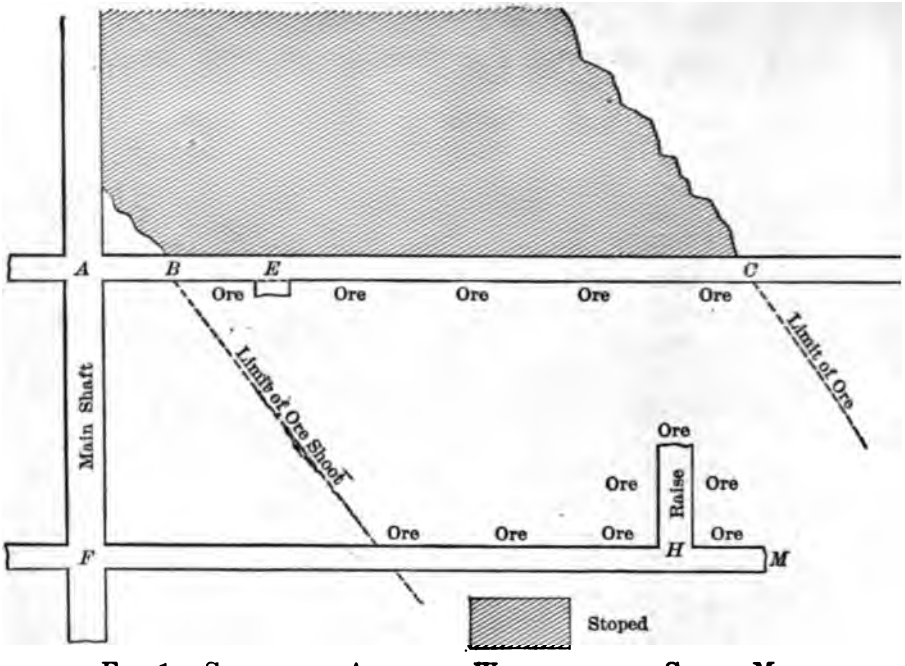


FIG. 1.—SECTION OF APPARENT WORKINGS OF A SMALL MINE.

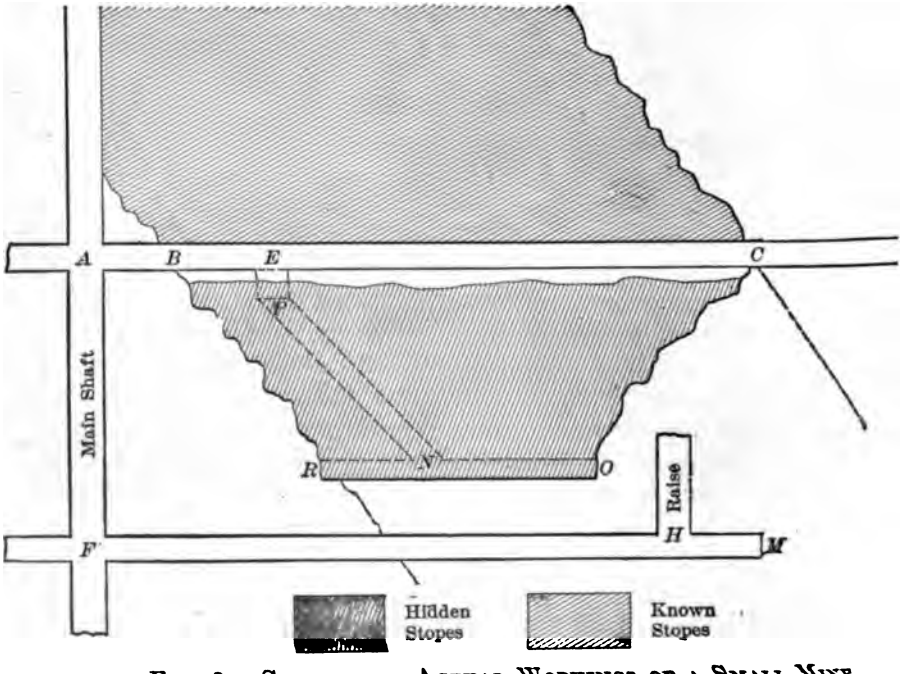


FIG. 2.—SECTION OF ACTUAL WORKINGS OF A SMALL MINE.

a vertical winze which is deeper than 5 ft., and has been carefully filled

of the cut [illegible] has been run down to [illegible] at A

[illegible] and all the ground [illegible] has been stoped [illegible]

[illegible] between [illegible] and [illegible] The raise [illegible] is [illegible]

[illegible] The [illegible] of the ore [illegible] has been taken out, and a

[illegible] has been attempted

[illegible] against the perpetration of such practical jokes it is not

[illegible] the manager [illegible] to [illegible] a statement which

[illegible] to [illegible] and to

[illegible] a map [illegible] of [illegible] ranges as are [illegible]

[illegible] a [illegible] was [illegible] to

[illegible] the engineer [illegible] the [illegible] manager

[illegible] from statements [illegible] with the intent to

Weighing Samples. In the [illegible] Works [illegible] and in

[illegible] will give a larger [illegible]

sample is taken along a parallel line the proportion will be maintained and a true sample will be secured.

The importance of an accurate recognition of the slope of a vein and the pitch of an ore-shoot, when making estimates, cannot be emphasized too much. An example will be of service. Thus: In Fig. 3 *A B* and *D F* represent an ore-shoot traversed by the two levels, which are 100 ft. apart. The ore has been stoped out above the upper level, and a portion had been removed between the levels. The stopes—inaccessible—above *B C* and the stoping begun at the bottom of the left-hand raise are calculated to obscure the real condition of affairs. The engineer samples the raise *E B* and the back of the level between *E* and *F*, with results which cause him to assume a block of ore, *A E F C*. He has failed to recognize the pitch of the ore-shoot because the stoping above *B C* has obscured it. It will be said that if he had sampled the bottom of the level this mistake might not have occurred, but the sampling of bottoms is not always practicable, and is usually

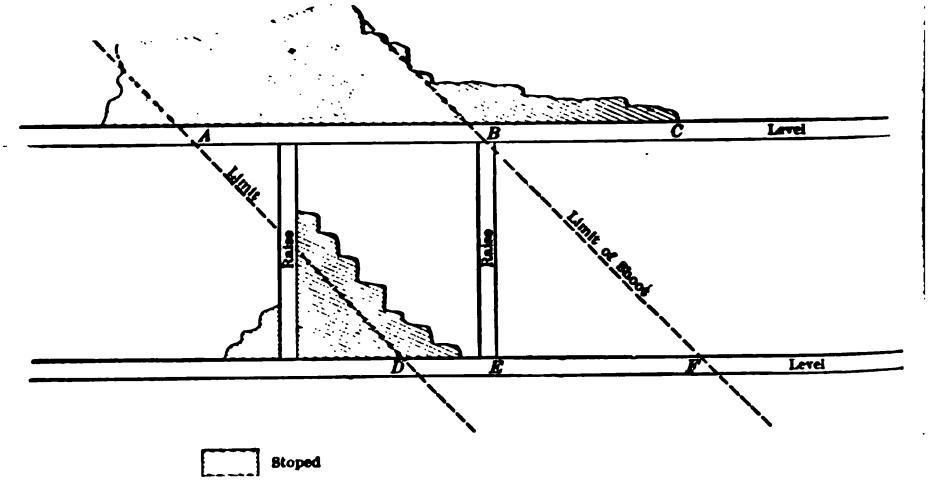
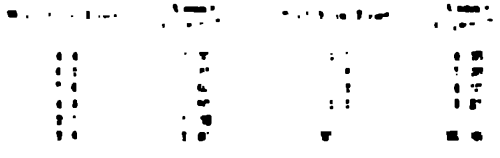
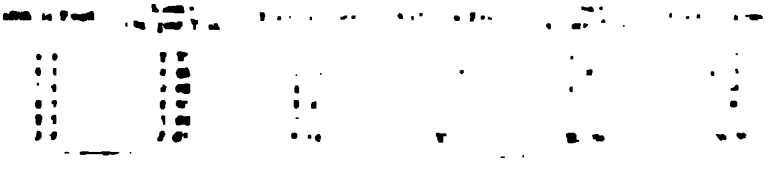


FIG. 3.—ORE SHOOT TRAVERSED BY TWO LEVELS.

very unsatisfactory on account of water and other factors. It is not realized often enough that ground which has been stoped was not necessarily profitable. Stopes are frequently started with the hope of an improvement or with the purpose of testing a run of ground. For this reason the workings of a mine, both underground and on the map, are apt to suggest unwarranted deductions as to the distribution of ore, and many misleading inferences have been caused thereby. Thorough sampling will usually make the truth clear to an experienced man.

Among the things to be avoided one must mention the so-called "grab" sample. This is the last resort of incapacity. A grab or haphazard handful of ore is taken indiscriminately from all over a pile of ore at the face of a level or in the stopes, and this is put into a small sack for subsequent assay. The idea of the grab sample is to shut your eye and be absolutely impartial, but the brutal fact is, that one usually gets a deceptive proportion of the fines and quite disregards the large pieces of waste or poor rock scattered through the heap. It is still the practice in





The average assay per foot of width is 1·71 oz. per ton, instead of 2·5 oz. In matters of this kind, mathematical reasoning confirms the conclusions of rough common sense. The method just described is based upon the higher mathematics, as the following integrations, kindly suggested by Mr. Ross Hoffman, will demonstrate:—

Problem 1.—To determine the average value of the section of vein A between

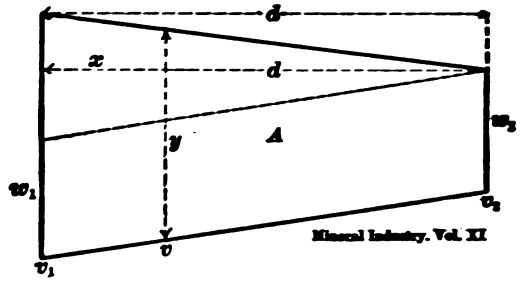


FIG. 4.—DIAGRAM ILLUSTRATING PROBLEM 1.

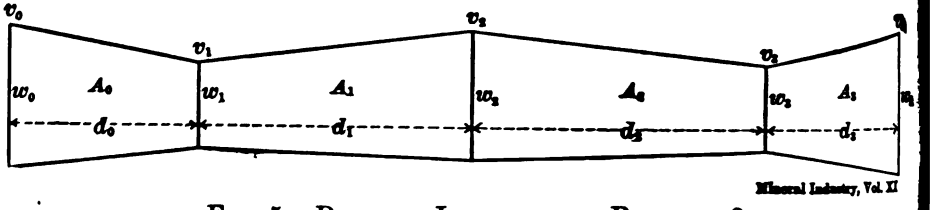


FIG. 5.—DIAGRAM ILLUSTRATING PROBLEM 2.

the samples whose widths are w_1 and w_2, and values v_1 and v_2, respectively, under the assumption that the values vary gradually over the area from v_1 to v_2 in the direction d, then at any distance x from w_1 the value (see Figs. 4 and 5)

$$v = \frac{x}{d}(v_2 - v_1) + v_1 \qquad (1)$$

also

$$\frac{d}{w_1 - w_2} = \frac{d - x}{y - w_2} \text{ or } y = \frac{x(w_2 - w_1)}{d} + w_1 \qquad (2)$$

$$A = \frac{(w_1 + w_2)\,d}{2} \qquad (3)$$

$\int_{x=0}^{x=d} v\,y\,dx \div A$ = average value for the section A.

From (1) and (2). $v\,y = \frac{x}{d^2}(w_1 v_1 + w_2 v_2) + \left(\frac{x}{d} - \frac{x^2}{d^2}\right)(w_2 v_1 + w_1 v_2 + \left(1 - \frac{2x}{d}\right)w_1 v_1$

$$\therefore \frac{2}{(w_1 + w_2)\,d}\int_0^d v\,y\,dx = \tfrac{2}{3}\frac{w_1 v_1 + w_2 v_2}{w_1 + w_2} + \tfrac{1}{3}\frac{w_2 v_1 + w_1 v_2}{w_1 + w_2}$$

$$= \frac{w_1 v_1 + w_2 v_2}{w_1 + w_2} + \tfrac{1}{3}\frac{(w_1 - w_2)(v_2 - v_1)}{w_1 + w_2}$$

The last term = 0 when $w_1 = w_2$ or $v_1 = v_2$.

[illegible] normal conditions where ordinary sampling can be depended on to give [illegible] estimate averages this last term will be small enough to neglect. (See [illegible]) Hence

[illegible] may be taken as the average value for section A.

[illegible]: To find the average value from a number of samples taken as [illegible] where w equals width of sample, v equals value, d equals distance between [illegible] and A, the area of various sections of vein between samples

$A_0 = (w_0 + w_1)\frac{d_0}{2}$ average value for A_0 $\frac{w_0 v_0 + w_1 v_1}{w_0 + w_1}$

$A_1 = (w_1 + w_2)\frac{d_1}{2}$ average value for A_1 $\frac{w_1 v_1 + w_2 v_2}{w_1 + w_2}$

$A_2 = (w_2 + w_3)\frac{d_2}{2}$ average value for A_2 $\frac{w_2 v_2 + w_3 v_3}{w_2 + w_3}$

$A_3 = (w_3 + w_4)\frac{d_3}{2}$ average value for A_3 $\frac{w_3 v_3 + w_4 v_4}{w_3 + w_4}$

(See Prob. 1)

[illegible] average value for A) / 2 A = average value over the whole area sampled

$$\frac{d_0}{2}(w_0 v_0 + w_1 v_1) + \frac{d_1}{2}(w_1 v_1 + w_2 v_2) + \frac{d_2}{2}(w_2 v_2 + w_3 v_3) + \frac{d_3}{2}(w_3 v_3 + w_4 v_4)$$

$$\frac{w_0 d_0}{2} + \frac{w_0 d_0}{2} + \frac{w_1 d_1}{2} + \frac{w_1 d_1}{2} + \frac{w_2 d_2}{2} + \frac{w_2 d_2}{2} + \frac{w_3 d_3}{2} + \frac{w_3 d_3}{2}$$

[illegible]

[illegible] terms represent areas and may be [illegible]

[illegible]

[illegible] samples are taken [illegible]

$$v_0\left(\frac{w_0}{2}\right) + v_1 w_1 + v_2 w_2 + \cdots + v_n\left(\frac{w_n}{2}\right)$$

$$\frac{w_0}{2} + w_1 + w_2 + \cdots + \frac{w_n}{2}$$

with the exception [illegible] increase in the general average proportional to the width of the sample

The two end sample values are shown to have half this importance, though in practice, with many samples in the average, it is customary to give the two end samples the full importance proportional to their respective widths.

In the calculations for tonnage the cubic feet of ore are converted into tons on the basis of a certain specific gravity; thus, quartz is usually taken at 15 cu. ft. per ton, while ores containing sulphides are rated at 8 to 12 cu. ft. It is not unusual to guess at this proportion because experience does enable an engineer to approximate the correct figure fairly well. But it is a dangerous practice. Approximations should never suffice where greater accuracy is possible. It is well to weigh a series of measured pieces of ore or to determine actually the specific gravity of a few pieces of average vein-stuff. Surface quartz, on account of its cellular structure, may require 20 cu. ft. to weigh a ton. Pyritic ores will vary to an extent hardly appreciable even to the experienced eye. Grevious errors in tonnage estimates have been caused by the assumption of an incorrect basis of calculation.

A minor source of error is sometimes created by the occurrence in the vein of numerous cavities, or "vugs," as the miners call them. In some cases they form a very appreciable proportion of the space occupied by the lode, so that they are apt to lessen the tonnage obtainable from a block of stoping ground.

The Question of High Assays.—In these calculations, whether they be mathematical or rough-and-ready, it is assumed that where two adjoining samples vary there is a gradation from one to the other. Generally the assumption is warrantable, but occasionally the difference between any two such adjoining samples is so marked, as to require further consideration. In the sampling of gold mines, especially where the metal occurs in a native condition and visible to the eye, there will be a few very high results which affect the average of a run of samples to an extent quite out of proportion to the importance of a single sample.

This question of high assays demands careful discussion. It can be viewed from two standpoints: the seller of a mine is apt to argue that if you are going to base an estimate of the ore-reserves upon the results of sampling and assay, you ought to take all the data without favor, just as they come, and that to eliminate high assays is no more fair than it would be to omit poor ones; to this the engineer, representing the interests of a possible purchaser, will reply that the occasional very high assays are largely accidental, that they affect the estimates to a degree out of proportion to their weight, and to an extent by no means comparable to the omission of an equal number of poor results; finally, he will murmur under his breath something about a factor of safety being necessary.

In the first place, it is incumbent upon the engineer to find out whether these occasional high results do, or do not, represent the average of the ore, not at the particular place sampled only, but over the whole space or interval which that sample is supposed to represent. Each sample, in the final calculation, speaks not for a spot but for a section of the vein, the length of which is the interval *between* samples and the height is the distance separating it from the next work*ing* overhead or underfoot; thus, when the distance between samples is 10 ft.

however, the fifth sample, which is very high, is eliminated the average drops to less than 1 oz. per ton, while, on the other hand, if the high sample is retained and the last two poor places are omitted the result is affected to a much less degree, the average then being about 3·75 oz. per ton.

In re-sampling these apparently very rich spots, it will be found that three contingencies may occur; the result may be corroborated or it may be proved to be accidental, while, should every high assay be found incorrect then there is a third possibility to be considered, namely, whether the samples have been tampered with. If, out of a considerable number of high results, not one is confirmed, then it is time to look around. If some are confirmed by re-sampling, while others are not, then, obviously, the values in the ore are erratic and a correction must be made for each case; if most of the high results are approximately repeated by the second sample, then it is evident that the first sampling was correct and that the ore is very rich in spots; intermediate samples must be taken, and when this is done the data for calculations will be complete. It is wise to take intermediate samples, both when the high assays are wholly, and when they are only partially, confirmed.

It has been argued by certain engineers that the mill or smelter always fails to confirm the very high assays occasionally obtained in sampling and that, therefore, they should be omitted as a factor of safety. This is not a fact. Exceptions occur. In the case of the Argentine lode of the Tomboy Mining Co., at Telluride, Colo., a careful sampling of a block of ground, at intervals of 10 ft., yielded an average of $7 per ton, all rich spots carrying visible gold being avoided. This work was done by an inspecting engineer of recognized capacity; nevertheless, the actual mill returns were $28 per ton. Nor is this inexplicable when the nature of the ore is considered. I have seen a piece weighing 25 lb., yellow with finely disseminated gold, so that it contained $100 worth of the native metal, which came from the breast of a level on a certain day—and the very next day the foreman's sample from the face of the same drift, which had been advanced two or three feet in the interval, yielded only 0·02 oz. of gold per ton! The Pandora vein, in the neighboring Smuggler-Union mine, affords another exceptional case; the mill results are usually higher than the assays, and this is explained as being due partly to the greater hardness of the rich ore, but chiefly because the gold occurs almost entirely in coarse particles which, being readily visible, are apt to be carefully shunned by the conscientious sampler. These instances are corroborated by the thoroughly experienced managers of the properties quoted. It remains to add that while it is true of the veins specifically mentioned, that the assays are usually lower than the mill returns, such is not the case with the Tomboy lode, which is near the Argentine, nor is it true of the Smuggler lode, which is intersected by the Pandora in the Smuggler-Union mine. The above are, however, well authenticated exceptions, which serve effectually to undermine a generalization which is the last resort of a timid engineer. Not that the factor of safety is to be discarded, quite the contrary: in all engineering such a precautionary measure is imperative, but do not introduce it *disguised*, face the facts, state them, and then introduce a factor of safety without any circumlocution.

e do sampling results differ from the mill returns? In the unusual in
e just mentioned, the difference was traceable to conditions which are rela-
ely rare but are always within the range of possibility. There is no doubt
n at all that the usual experience, of finding the mill extraction below the
ate based upon sampling and assay, is traceable to the fact that rich ore
ccurs in the softer, more crumbly parts of a hole, or it is associated with
ubs which are not only easier to break than quartz, but they also make a
g mark which invites the blow of the mud and hammer. This aspect of the
n emphasizes the weak factor in sampling, it is not absolutely mechanical,
t still not a machine does the work, and the results partake of that liability
or which is essentially human.

ust be asked, in conclusion, what course should be adopted with high assays
t are not possible to re-sample. Frequently, the samples are not assayed
by mine, but are taken, or sent, by the engineer to a reliable assayer living
istant locality. Time, an element in all business matters, may prevent the
ne from returning to the mine to take further samples. This is a dilemma
frequent in current practice. Judgment and experience must decide. The
e frequency of high assays, the degree to which they affect the final esti-
the character of the ore, the results of sampling as compared to the actual
nd average of the mine, the character of the w[illegible] by the engineer
e accessible, these and similar factors will determine the decision. Have
I laid down rules to direct any man's judgment?

ust be permitted to say that if you are uncertain of your results—don't
ess. Do not let yourself be hurried, either by your client or so as to more
ch by the vendor, to commit yourself to a decision based upon data,
ome of which, in your own mind, are doubtful. It is better to be sure
ong.

Possible Discrepancies between Sampling and Working.—In sampling the
ge it is necessary that the engineer should have some definite purpose in
the mine is being worked. It is useless, for instance, to sample 2 ft. of
matter without any regard to the fact that in stoping it is the practice to
e a width of 4 ft. Unless judgment is exercised the samples are apt to
ot cleaner ore than the stopes of the mine, so that the estimates based
thereon will be misleading. [illegible] for treatment to mill re-
y may differ from the ore [illegible] shown in the estimates based
n. Thus—

The hole may be [illegible]
presentative the mining of a [illegible]
The hole may be so [illegible] g but may have
g of soft rock which breaks [illegible]
to increase the tonnage and [illegible]
The hole may be built of [illegible] ly the
d through it, so that in stoping [illegible] a large and
e width.

he preliminary trip through the mine should be made with a view to
rection, together with the information obtainable from either the foreman

or the manager, how the ground is being worked, and how the ore is being handled. If he does not secure these data at the preliminary examination, he will light upon them in the course of his investigations into costs, for without them the relative expenditures at mine and mill will be contradictory, if not unintelligible.

Concerning the conditions first mentioned, under the heading A, it is obvious that the width broken in stoping has a minimum, which in ordinary practice varies according to the method employed; that is, with hand labor a width of from 2 to 3 ft. will ordinarily suffice; while at least from 3 to 4 ft. is necessary when machine drills are used.[1] In both cases this minimum width will be exceeded if the rock is very hard or if it breaks along easy lines of fracture, which cause more rock to be taken down in blasting than is absolutely required for mere convenience in working. If the streak of ore is less than the width of the stope there will be, inevitably, an admixture of waste, except in the rare cases where it is practicable to strip the pay-streaks, that is, stope the country without removing the vein, which is subsequently taken down separately. This method, which is covered by the Cornish term "resue," is excellent when the vein of ore is narrow, but it depends for success upon the ore being closely attached or "frozen" to one of the vein walls, so that it will not be shaken down when the adjoining waste is shot away. In many mines in Colorado, Montana and Idaho, especially in the case of narrow streaks of very rich silver ore, it is not unusual to spread canvas or sacking along the floor of the stope and then break down the ore upon it, which in this way is kept free from admixture with waste, and can be sacked without any sorting. The canvas is covered for protection with 6×3×12-in. timbers. In such a mine as this the sampling of the vein itself would give data which closely approximate the actual returns from ore sent away to the smelter.

When it is not possible to mine the ore separately from the waste it is usual to pass it over the sorting tables, where the waste is picked out by hand. In the determination of the percentage thus eliminated lies the difficulty of getting the proper relation between the assays of the ore as sampled and the value of the material as sent to the reduction works. Unless this is determined, and the sampling is corrected in accordance, the figures of the engineer will not harmonize with the results of future operations. The most practical way to find out the percentage sorted out is to measure the ground stoped during a given period, and, knowing the tonnage extracted from such a particular block of ground, to determine the average width of clean ore actually obtained from that block. If the average width of the vein is fairly consistent one can, from these data, deduce the amount of waste which gets mingled with the pay-streak and then correct the assay returns, from sampling, accordingly.

However, gold-veins are rarely uniform in width, and, moreover, any given mine may contain several lodes, the output of which is not kept separate. In such localities as Kalgoorlie and Cripple Creek where the veins are rich, erratic, and so diffuse in their mineralization as to make it compulsory to break down a great deal of waste in extracting a small width of clean ore; where, also, the large

[1] A small (2·25-in. cylinder) drill usually requires a stope of from 3·5 to 4 ft. in width, the large air drills (with 3·5-in. cylinder) take from 4·5 to 5 ft.

unavoidable exigencies of business, which unfortunately do often hamper, hinder and obstruct the engineer in his professional work, it is possible to arrive at the ratio of ore and waste, and, therefore, to formulate accurate estimates. It requires time and it needs money, but, in the examination of large mines nowadays it is appreciated by financiers and syndicates employing first-class engineers that they must make provision for plenty of time and money in order to get good men to do good work. This may seem a digression, but it vitally affects the consideration of this branch of the subject under discussion.

When, therefore, conditions do permit of every precaution, the engineer will cause the ore, as it comes to the surface, to be weighed, he will get the weight of the clean ore after sorting, and he will check this with the weight of the material which goes over the dump. He will also take samples of the dump to correct his estimate of the average values. The weighing and sampling will, of course, be done by his own men. He will also take careful note of any waste which is retained underground, as is usually the case in a well-managed mine. If this is done during the space of a month or so, which is the minimum period permissible for an important examination, he will have data enough to enable him to correct the results secured from the sampling of the mine. In the suppositious case, quoted above, the 1 ft. of 4-oz. ore would be mined (and sampled) with three times as much waste, one-half of the material thus broken would be sorted out at the surface and with it would go some of the fines, so that the net result might be about 2 ft. of ore assaying 1·75 oz. and 2 ft. of waste assaying about 0·25 oz. per ton.

These final estimates should be borne out by the future record of the mine. As a safeguard, however, the engineer ought to state in detail, in his report, how he arrived at his figures, lest, later on, an ignorant directorate or an unscrupulous manager should either work more than a proper width, in order to get an increase in tonnage, or mine only the richest portion of the lode with a view to a brief period of inflated returns. Such things have happened and honest men have been drawn into the blame which followed.

Coming to the consideration of the second point, specified under B, it is evident that here also there is room for error. In most lodes of gold-bearing quartz, where sorting is out of the question on account of the low grade of the ore and the uncertain dissemination of the gold, it is not possible to break the ore in the stopes as clean as it is broken in the course of sampling. Should the lode be free from an admixture of country it is nevertheless rarely practicable to stope it without bringing down some of the encasing rock. This is slight in some instances of very well-defined quartz veins, large enough to admit of a full-sized stope and so separated by selvages from the wall-rock as to come clear away. In most instances, however, the stoping will include a large proportion of waste, and when it happens, as is not infrequent, especially with big generous ore-deposits, that the lode throws out branch-veins or is enriched by feeders, then it will be found that there is a very considerable admixture of comparatively barren rock.

Circumstances such as these, overlooked or underestimated, have been at the root of the differences between the estimates of capable engineers and the subsequent record of the mines they have reported upon. Managers, as a rule, like

[illegible] the [illegible] character of their operations, and are apt to accentuate [illegible] at the ore [illegible] and free from wall rock. Moreover, in all [illegible] an element of the unexpected, which in this case takes the form [illegible] away of [illegible] of wall rock, the admixture of large pieces of [illegible] the occasional [illegible] or intrusion of barren rock, and a wealth of ore [illegible] all of which tend inevitably to an increase of tonnage [illegible] in the average value of the output. One must look for these [illegible] and obtain data sufficient to warrant an estimate of their [illegible] upon the accuracy of these calculations which are at first [illegible] the results of sampling.

[illegible] include a large proportion of the big low grade bulks [illegible] much of the metallic wealth of the world is derived. An examina- [illegible] is usually confined to those workings which are confessedly profit- [illegible] to become so. The non payable workings are neglected. In actual [illegible] however, a level or a raise is apt to be carried forward through poor [illegible] the hope of encountering better ore, and it is not uncommon to remove [illegible] unprofitable ground lying between good stopes because of practical con- [illegible] working. In this way there is a tendency to offset the results of [illegible] not corrected in accordance with a recognition of such indubitable [illegible]

[illegible] in the working of large stopes to [illegible] where the [illegible] is not determined by well defined boundaries, but is left to [illegible] of the assay, as a consequence [illegible] [illegible] to increase the stoping width. The result of a steady increase [illegible] working costs, due to better management, improved [illegible] and [illegible] [illegible] of the exploitation. [illegible] [illegible] neglected [illegible] [illegible] [illegible]

imperative that a clear conception be had of the fact signified by the technical terms employed when it is found that they are robbed of sense as soon as they are dissected. Therefore it is necessary to discard them and seek for better ones. "Ore in sight," as used to describe the ore-reserves of a mine, is, if taken literally, a contraction in terms and, if taken otherwise, it has an elasticity which has caused many to stretch it until it has become so indefinite as to include the ore which is beyond even the most imaginative vision.

In order to express the results of careful sampling and estimation by a phrase which will at once convey its meaning, even to the untechnical, I would suggest "ore in reserve and ready to be broken," or "ore ready for stoping."[2] This would cover those parts of a mine which have been so cut up by systematic workings as to permit of very close calculations. Next would come the blocks of ground incompletely developed, but known to carry ore, which, in character and persistence, is similar to the main portion of the mine. These could be covered by the term "probable ore reserves." Beyond this point a careful engineer will not go, avoiding "possible ore reserves," or any similar phrase, as a snare of the devil, because of the great likelihood that his client, or the shareholders who may follow, will disregard the qualifying adjective and commit him to a meaning which he did not intend to convey. When it comes to the chances of development, itself a most important part of the engineer's exercise of judgment, it will be best to include the consideration of this aspect of the inquiry under the paragraphs which deal with "the future prospects of the mine."

That is reserved which is stored for future use, therefore that which is to be used forthwith is not in reserve, from which it follows that by "ore-reserves" is meant such bodies of ore as are kept back for the present with a view to future use, when those are exhausted which are now being stoped. A mine which is being stoped at a rate so rapid in ratio to its development that it has, at any given time, only enough ore to keep the mill going for a few palpitating moments cannot be said to have any "ore-reserves." The idea of the latter includes a reservoir of supply not to be exhausted at short notice. As a consequence of these considerations it is obvious that the amount of ore which warrants being entitled "reserves" will depend upon the relative size of the reduction plant which is attached to the mine.

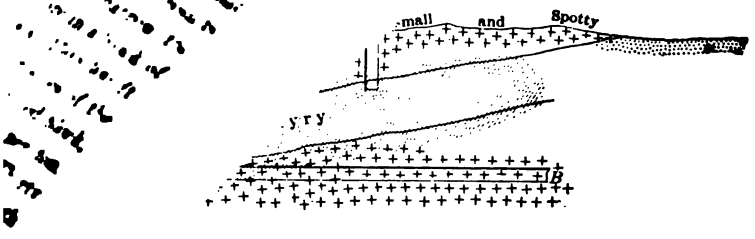
At the outset it is permissible to quote the famous dictum of President Cleveland, in referring to the tariff, "It is a condition which confronts us, not a theory."[3] Any attempt to establish uniformity of procedure in the estimation of ore reserves is bound to break down because it disregards the inevitable diversity of the conditions which obtain in mining. Mines differ, as men do. A safe presumption in one case is a hazardous guess in another. During a recent discussion of this subject it was suggested that it was desirable for mining engineers to agree upon certain general rules, as to the allowance to be made in estimating ore. You might as well sign an agreement upon the percentage of trust to be placed in human nature. There are mines, the ore bodies of which are of such a char-

[2] This discussion of terms was written some time ago, before Mr. Argall brought forward the sensible suggestions which appeared in the *Engineering and Mining Journal*, Feb. 14, 1903.

[3] *Messages of the Presidents*. Richardson. Vol. VIII., p. 580.

to 8, which marks rich ore. The results are in-
nce, as to the amount of ore in the mine, is

ded by his sampling alone; he has
v happen that the superinten-
told him that the ore is
the rock does indeed



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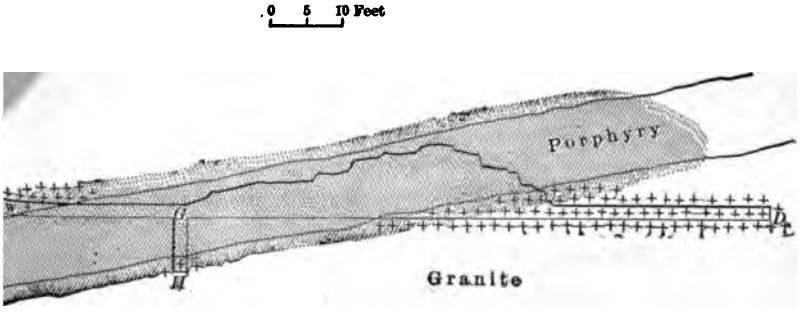


Granite Porphyry Ore Bodies

ECTION OF WORKINGS SHOWING THE GEOLOGICAL FEATURES.

places, this variation does not seem to affect the general distribu-
. Or, again, it may be, as happens often, that the man in charge
honest, but not honorable, and, instead of committing himself to
ts as the foregoing, he keeps discreetly silent, or, under cover of ap-
ain from influencing our young engineer,[5] he absents himself while
is in progress, and leaves his shift-boss or some other underling to
. Perhaps, indeed, those in charge of the mine really do not appre-

d the blunder to be due to youthful inexperience, for this is the least blamable, but as a
ders of this kind are due to ignorance and are frequently made by older men of the kind
ughly practical" where the particular emphasis on "practical" is indicative of utter lack
echnical education as an engineer requires.

mine, its future possibilities, the geological environment, economic conditions and other factors of primary importance.

Inferences from Sampling.—When the sampling has been thoroughly done the engineer is in possession of many important facts. If he is a novice he will have learned the assay value of the ore at each of the spots he has sampled and he will have learned little else.

Nothing illustrates so well the proverb that "a little knowledge is a dangerous thing," as the direct inferences from the results of sampling. To emphasize this

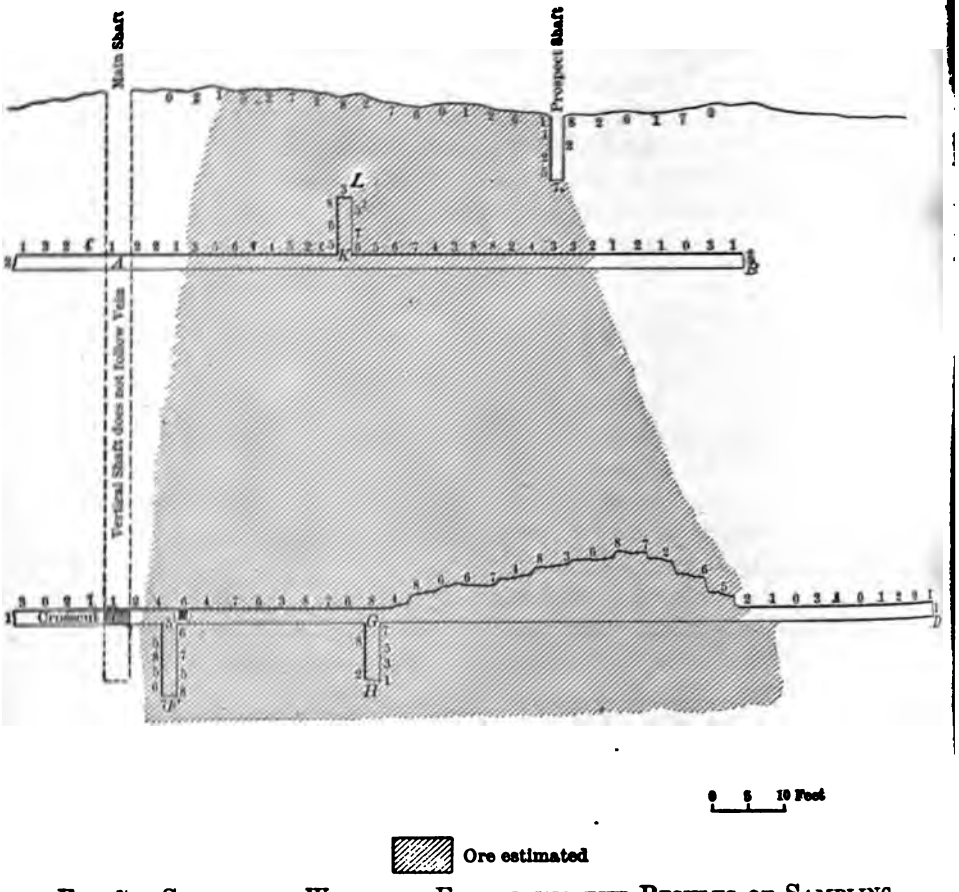
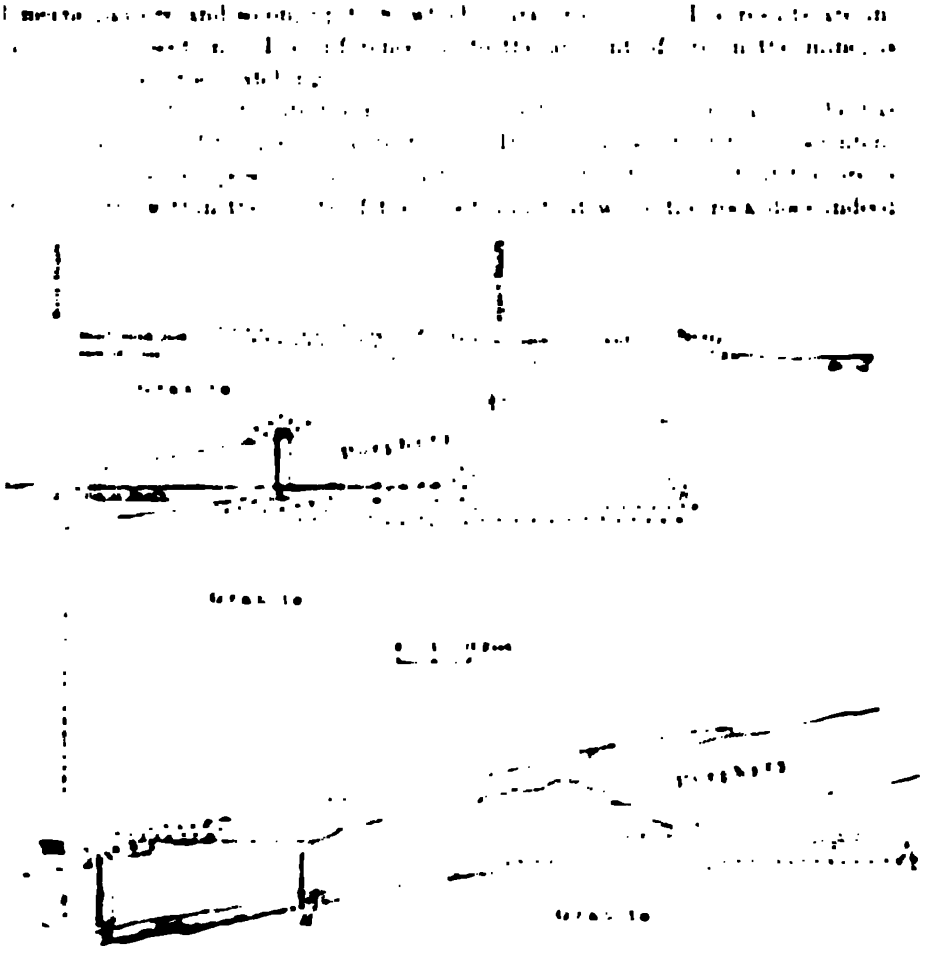


FIG. 7.—SECTION OF WORKINGS EXHIBITING THE RESULTS OF SAMPLING.

statement, I will take an instance which is founded on fact. In Fig. 7 a longitudinal section of a small mine, which has been apparently well opened up, is illustrated. The shaft is vertical and does not follow the vein, which inclines to the west. The levels to the north have found nothing, those to the south (*A B* and *C D*) have cut through ore which is also explored by a raise (*K L*), and two winzes (*E F* and *G H*). At the lower levels, stopes have been started and the "backs" make an excellent showing, as the figures indicate. The latter are not expressed in any particular unit, but it is to be supposed that zero means barren,



ciate the true condition of affairs, and the engineer is deceived by an oversight which will appear almost excusable. However, the mischief is done, the mine is taken over by a financial syndicate or a mining company. Before the business is actually consummated, another engineer, representing another financial interest, is sent out to make an examination. Suppose that this man is of greater experience than the last; he is, moreover, familiar with the geological structure of this particular district or of another similar to it. He proceeds to sample. The accuracy of the previous sampling is confirmed, but in the course of his investigation he has noticed that the country is not uniform, and that there are two different rocks exposed by the workings. One is obviously granite, the other he cannot label accurately without a microscopic section, but it is evidently an eruptive which has intruded into the granite; so, on account of its speckled appearance, he applies the term porphyry to it, and when the sampling is finished he spends a few days in carefully examining the workings with a view to getting an idea of the structural relations between these two rocks. The results are set down

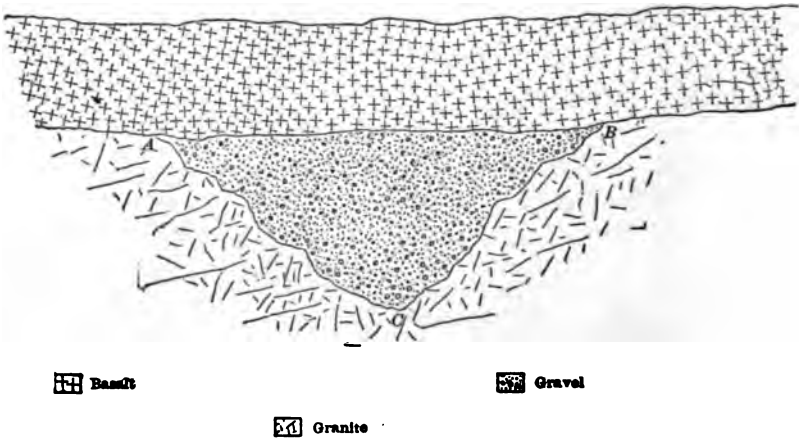


FIG. 9.—CROSS-SECTION OF A DEPOSIT OF TIN GRAVEL.

graphicallly and he obtains the information illustrated in Fig. 8. By examining this section, side by side with Fig. 7, it will be seen that his inferences are warranted. The consequences are surprising. He discovers that there is no continuous ore-shoot from the surface downward, but that there are two comparatively small lenticular ore-bodies which occur where the vein cuts through the porphyry sheets, and only in those portions of the porphyry where certain cross-veins have exercised an enriching effect. When the vein gets into granite it becomes poor, and, moreover, it pinches, a fact which the sampling did not sufficiently emphasize. The ore-reserves are cut down to a fraction of the previous estimate, and the future prospects of the mine are considered most uncertain, because the ore already found is due to local structural conditions which are unlikely to recur.

Another kind of error may be instanced. It is more frequent in placer mining than in the estimation of ore in lodes. Fig. 9 represents the cross-section of a *deposit* of tin gravel in an old river channel now capped with basalt. The deposit was sampled through shafts which cut right down to the gutter, 180 ft. deep,

hundred feet downward, and on the contrary, you will be playing with Providence if you assume the continuation for several hundred feet on the part of an ore-shoot which has as yet been traced for only 50 ft. from the surface. In this respect the mines of the Rand afford a striking contrast to most precious metal mines. The banket, in comparison with the ordinary type of gold-vein, has the persistence and uniformity of a coal-seam, and explorations on a large scale all over a very extensive region will warrant an engineer in making assumptions which would be ludicrous in California or Colorado. Yet, even under these exceptional conditions, such general evidence of continuity, when applied to an individual mine, must be amenable to the particular testimony obtainable in that particular mine or in the workings of its immediate neighbors. In most gold mining districts there is such an absence of uniformity in the structure and behavior of gold-bearing lodes that it becomes imperative to rely upon the particular testimony afforded by each mine. Such testimony, however, must be read in the broad light of experience. For this reason the estimates of ore likely to be opened up by further development will be more nearly correct on the Rand than similar calculations made by the same engineer elsewhere. Another distinction obtains; a precious metal mine in Colorado or California, by reason of mining laws which give the owner of the outcrop the right to follow the vein indefinitely in depth, has a future which is not confined to the narrow limits of mere acreage, such as is imposed in the Transvaal, in Australia, Mexico, etc. This renders the future of the American mine more speculative, while at the same time it lays upon the engineer the responsibility of appraising possibilities which are quite beyond the limits of ascertainable fact. It is no solution of the problem to say that such possibilities have no assessable value, for to adopt this attitude is to disregard the entire history of precious metal mining in the Great West, and the engineer who rests content with the evidence which is before his nose will prove but a disappointing, and often misleading, adviser to an enterprising client.

In arriving at general conclusions concerning the persistence of an ore-body in a mine, the engineer may have several guides, namely, the internal evidence afforded by the behavior of the ore-body in the ground which he has examined, the collateral suggestions afforded by the behavior of other ore-bodies in the same mine, the general evidence obtainable in other mines within the same region.

When the value of a mine centers upon one large ore-body, rather than several, there is no opportunity for inferences founded on similarities of behavior. The engineer is compelled to seek for internal evidence. If the sampling has been properly conducted and the results have been set down on the longitudinal section of the workings it will be found that the ore exhibits local variations from which certain deductions are possible. The relatively richer parts of the ore-body may be so distributed as to indicate mere absence of uniformity, and nothing more, but, as a rule, the indications will go further and suggest either that the ore-body is becoming richer with increasing depth, or poorer in the same direction, or that there are successive zones of richer or poorer. Again, the lode may be as rich as heretofore, but a change may be apparent either by way of a shortening of the ore-shoot, or of a narrowing of the pay-streak. For all these possibilities one has to search amid the tangled mass of evidence.

two instances will serve to illustrate such possibilities. In the San region of Colorado the prevailing geological formation is a volcanic breccia, tertiary age, built up of fragments of andesite, which are arranged in nearly vertical layers. The veins cut through this rock without, commonly, causing very big dislocations. In these gold-bearing quartz veins there occur ore-shoots having a pitch which is usually not far from the vertical, and while such shoots may be worked out in their entirety so as to exhibit an unbroken extent in the stoping, nevertheless to those who are observant of the variations in grade of the ore, as recorded by the assays or weekly mail returns, it is found that such variations correspond with the changes in the country, that is to say ore-shoots will be characterized by nearly horizontal bars of enrichment or are traceable to the effects produced upon the veins by the particular layer of rock through which it is passing at a particular horizon. My observations lead me to suppose that the composition of certain layers of the fragmental volcanic rock is responsible for the effects noticed and that the layers which have the

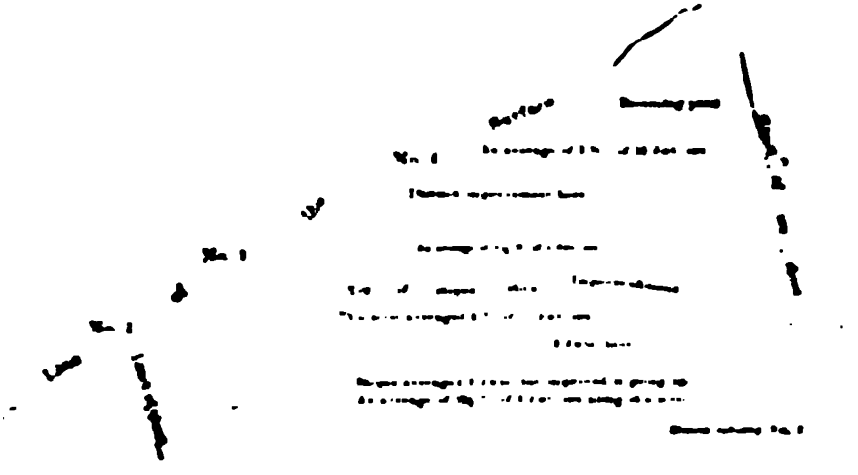


FIG. 10.—SHOWING RESULTS OF SAMPLING.

texture are those which are the most favourable for the formation of the ore-bearing fissures. The examination of the [illegible] In [illegible] it was found that a vein had penetrated a stope [illegible] movement which gave it a [illegible] to that of the [illegible] to the instant where the [illegible] grade. The [illegible] to level and the end of it [illegible] the [illegible] of the existence of an ore-shoot of a low grade order. In the stopes [illegible] change to record [illegible] No. 2 is approximately corresponding with this level [illegible] No. 1 [illegible] a better showing, and average [illegible] 11 feet for an average of 4 ft. Here also [illegible] the corresponding [illegible] No. 1. The stopes above No. 2 gave results as good as the [illegible] all, so as to average *one half* the results given by the No. 2 level. At No. 3

the average of the level is only 3·5 ft. of 4-dwt. ore; this is doubtless the reason why the drift was not extended to the limit of the shoot. A raise put up from this level is in poor ground until within 50 ft. of No. 4; then marked improvement sets in. This is confirmed by the results from the No. 4 adit, which gives an average of 3 ft. of 10-dwt. ore. This good mill stuff, however, does not extend much above the level, as is proved by a raise, which gets into poor ground.

These data are perplexing and indicate an alternation of values which renders any estimate very hazardous. When, however, the geological structure is investigated, there is found to be a relation, between values and structure, which illuminates the entire problem. In Fig. 11 there is given a section, on the plane of the vein, which exhibits the position of the series of layers through which the vein cuts. This helps to explain the results shown in Fig. 10. The zones of enrichment penetrated by adits No. 1 and No. 4 coincide with two layers of close-textured tuff, or fine-grained breccia, laid down during the intermittent violence of volcanic

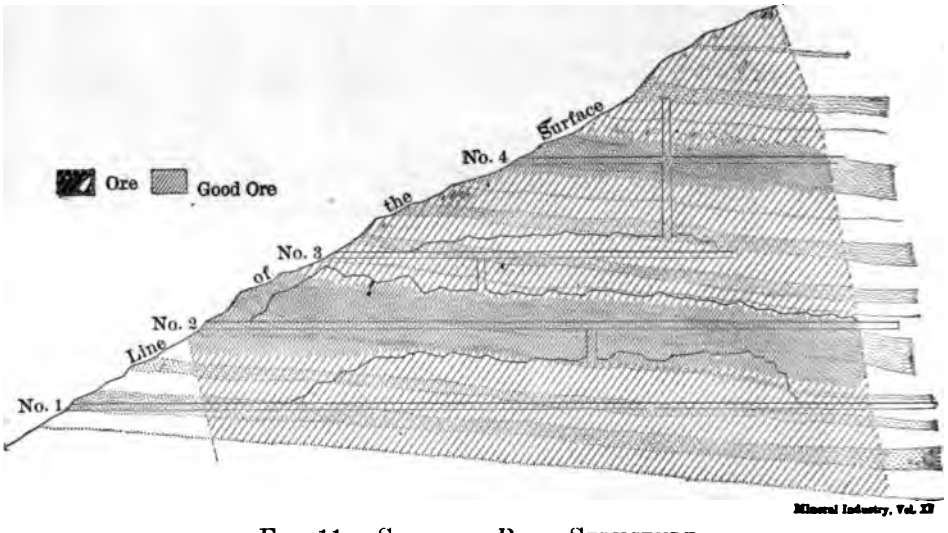


FIG. 11.—SHOWING ROCK STRUCTURE.

eruption. The intermediate, overlying, and underlying beds of breccia are coarse, and, for some reason which does not concern the present inquiry, they are less favorable to ore-deposition than the occasional layers of tuff.

In this instance the evidence was very clear; in other mines situated in the same region it is not practicable, on account of the decomposition of the enclosing country, to establish the relationship so clearly, but it is a matter of experience that notable variation in both the width and value of the lodes does occur in a similar nearly horizontal direction. The understanding of it is, therefore, a clue to many apparent vagaries in the distribution of rich ore.

In the case of a mine which contains several ore-bodies there are many useful suggestions to be obtained from a comparison of their characteristics. Careful investigation will lead sometimes to the detection of peculiarities applicable to the general occurrence of ore in that particular mine. The longitudinal section of the

warrants the close study given by a general to the map of the region which be the scene of his campaign. Stope-maps are not always correct; sometimes are incorrect to a very misleading degree. A few measurements, at least, ould be made to test this point, and occasionally, when the general accuracy the surveys warrants a doubt, it is a good precaution to make one's own map the mine, either personally, or by engaging the services of a reliable surveyor. e conditions are so diverse that it is impossible to give a typical illustration, but, by way of suggestion, I will append an example of inferences derived from a study of the old workings of a mine. It is a small mine; for, after all, e most perplexing of problems is a prospect, and it is found in practice that e greatest mistakes and the exercise of the keenest judgment are alike ex-

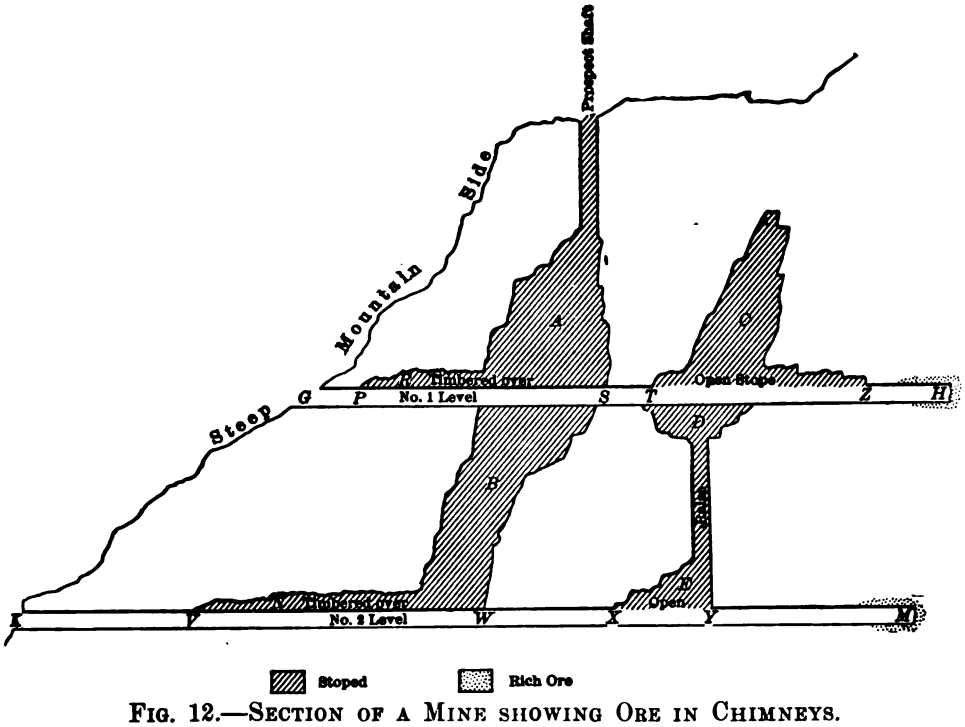


FIG. 12.—SECTION OF A MINE SHOWING ORE IN CHIMNEYS.

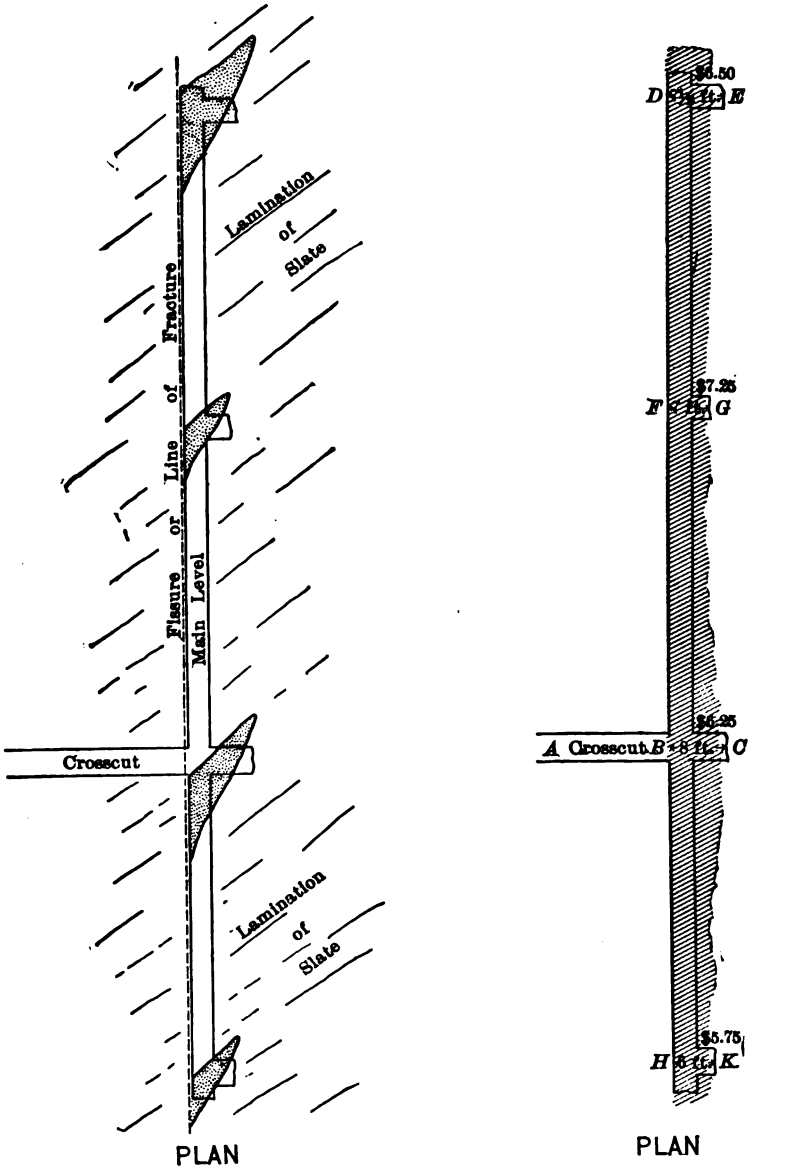
hibited in the appraising of the uncertainties of an undeveloped mine; therefore, the size of the property chosen as an illustration scarcely requires apology.

Fig. 12 represents a section of the workings. These consist of two adits, on the vein, together with a discovery shaft, which joins the upper level (*G H*), and a raise connecting the latter with the lower level (*K M*). The problem is to determine what weight should be given to the occurrence of a good width (say, 4 ft.) of very rich ore (say, 5 oz. gold per ton) in the ends (*H, M*) of the two levels. In such a case it is most important to investigate, with thoroughness, the mode of occurrence of the ore-bodies previously encountered in the mine. This is not always easy; old workings have been allowed to cave or the ground is heavy and they are carefully timbered so as to impede examination.

Sometimes this is intentional. In the case cited the upper level appears to carry one continuous body of ore from *P* to the breast at *H*, with a small comparatively barren interval *S T*. The timbering obscures the fact that the first half of the stope *P S* is only a cutting-out stope, which was worked for the purpose of testing a low-grade portion of the vein; the same applies to more than two-thirds of the stope *V W*, at the lower level. Similarly, while the timbering between *T* and *Z* indicates a good length of stope, as a matter of fact the innermost half of this is little more than a "cutting-out" stope in comparatively poor ground. The truth is, the ore-body *A B* did not go to surface, having been first cut by the discovery shaft at 70 ft. down; it is a very short body of ore, almost a chimney, and it diminishes in approaching the lower level; further, the ore-body *C D* is still less persistent; it is a narrow, short lens which does not hold out to the lower level, nor does it go up more than half way to surface, but it makes a sort of spurious connection, by means of the raise, with another patch of ore, *E*, on the second level. In practice, such workings as these are largely inaccessible, and usually dangerous; as a consequence, the statements of an inaccurate superintendent, who desires to serve his employer by putting things in the most favorable light, are apt to carry more weight than they should, so that, with the usual desire for quick decision on the part of both the vendor and the vendee, the engineer may be pushed to a conclusion which the actual facts do not warrant. It may seem to one who has missed the essential character of these ore-bodies, through the failure to examine the old workings, that the good width of rich ore at *H* and at *M* indicates the beginnings of a big body of ore which persists, at least, from one level to the other, but, to another man, who has carefully studied the old workings, it is evident that the probabilities point merely to another narrow lens of uncertain extent. The moral is, do not allow yourself to be hurried into an opinion by either party to the transaction, and beware of workings which are stated to be inaccessible, because such inaccessibility may have a purpose.

Another illustration will emphasize the warning conveyed in the last sentence. In Fig. 13 is represented the single level of a Californian mine which is reached by the western cross-cut shown to the left of the drawing. The level is 450 ft. long; owing to the fact that the country is a soft, black slate the ground is very heavy and the level is closely timbered throughout, permitting of only occasional glimpses of ore at the points where short cross-cuts have been run out eastward. At these places, *D E*, *F G*, *B C* and *H K*, the lode is plainly visible and exhibits from 6 to 8 ft. of fairly uniform quartz carrying an average of from 6 to 7 dwt. gold, in a district where working costs are about $3 per ton. After sampling these cross-cuts, examining the little there was to be seen, and finding that the ground really seemed heavy enough to justify the close timbering over the level, the engineer came to the conclusion that he was dealing with one of those persistent ore-bodies not uncommon in that part of California, and he estimated the ore to have the continuity exhibited by the cross-hatching in the drawing. However, he had wholly misunderstood the real character of the ore-occurrence, as Fig. 14 will indicate. The close timbering was not necessary in order to sustain the ground alone; it was an excuse for obscuring certain facts. The quartz exposed by the several cross-cuts belonged to a number of small lenses. These abutted

ainst the "fissure," or main line of fracture, which constituted the supposed le; the lenses were short-lived and lay with their longer axis parallel to the



FIGS. 13 AND 14.—SHOWING LODE STRUCTURE AND METHOD OF SAMPLING.

ayers of slate; the body at *D E* only lasted as far as two sets of timber; that t *F G* died out at 60 ft., and that at *B C* "petered out" at 40 ft. above the level,

while the last one, *H K*, went up as a narrow body for a distance of 160 ft. Compare Fig. 10 with Fig. 13 and quote Hamlet's comment on his own portrayal of his mother's successive husbands. This incident did not befall a tyro, but an old campaigner, who was caught by his own carelessness under circumstances from which only the greatest wariness could have saved him.

Misconceptions concerning the conditions contributory to the localization of ore shoots and the consequent mistaken ideas as to the future possibilities of a mine have often arisen from a misunderstanding of vein intersections. In the case of a well-known mine in southwestern Colorado, a length of 2,700 ft. of ore had been opened up by an upper level, and stopes, which had worked out most of the ore except at one end, had proved that it persisted to the surface, an average distance of 150 ft. above this upper level. In the meantime two winzes had demonstrated the apparent downward continuance of the ore-body. A longitudinal section of these workings is shown in Fig. 14. In the examination of the mine by several distinguished mining engineers, it was assumed that the winzes, one of which was 58 ft., and the other 143 ft. deep, proved the continuity of the ore-body to an extent sufficient to warrant a price for the property

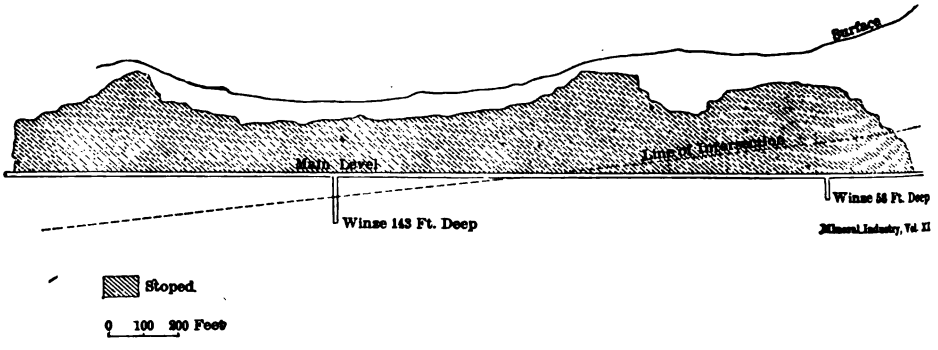


FIG. 15.—LONGITUDINAL SECTION.

which was a good deal in excess of the net profits to be won from the ground as measured to the bottom of the winzes. In the sequel it was found, after the mine had been purchased and when deeper workings had explored the lower horizon, that the ore-body owed its existence, and certainly its shape and position, to the intersection with another lode. This made a "scissors crossing," the hinge of which was a line, dipping west at an angle of 7° 30′. The ore-body reached from this line to the surface, while downward it extended about a hundred feet or so. Other scattered smaller bodies of ore were, it is true, encountered, but the main ore-body of the mine, upon which its value was based, extended only about a hundred feet below the broken line shown across the longitudinal section in Fig. 15. Such an instance as this proves the need for deciphering the conditions which have affected the distribution of ore. The crossing referred to was visible in the stopes at the east end, but only to an inquiring observer who suspected some eccentricity of lode structure.

Collateral Evidence.—Of all the collateral evidence likely to aid the engineer in a correct diagnosis of the condition of the mine he is examining, none is so

eful as that derived from a study of the surrounding district. Mines situated the same district are apt, on account of an identical geological environment, exhibit similar symptoms and to suggest like possibilities. The general study a region, therefore, is a useful preliminary to the investigation of a particular ine. Moreover, there is, I am glad to say, a certain spirit of *camaraderie* among rofessional men of the right sort which will enable a stranger to obtain many seful hints from resident engineers if he is properly made known to them.

The characteristics of ore-deposits within limited areas are often well marked; n one case persistence, without probabilities of bonanzas, is the rule, as on the tand; in another case an irregular distribution of values is to be expected, as n most silver-lead deposits in limestone and also in many rich telluride veins here secondary enrichment has been at work; again, certain lines of faulting nd well-defined contacts between sedimentary and eruptive rocks may be recogizable as factors in determining the place of rich bodies of ore, as is illustrated y the Aspen and Rico districts in Colorado.

Another very important factor, in influencing the relative richness of a lode in epth, is the position of the ground-water level. No engineer can afford to disgard it. Two opposite cases may be cited. In certain arid regions of the southestern part of North America, which it would be invidious to specify further, ie persistence of rich ores coincides roughly with the zone of oxidation. I recall well-known mine which, at the time it was examined by several reputable engieers, exposed an ore-body nearly 1,800 ft. in length. This was the length of ie ore traversed by the longest level, which was also the deepest. (See Fig. 15.) oth ends of this level were, however, still in ore. Three winzes proved the ore or a further depth of about 30 ft. The upper workings contained carbonates lead and iron-stained quartz rich in the precious metals. At the third level ere was evidence of the edge of the oxidized zone, for sulphides predominated. ll of the winzes left off in sulphides, of average tenor as regards gold and silver, t exhibiting a noteworthy admixture of zinc blende amid the galena. One gineer who examined the mine allowed 50 ft. below the lowest level as ore to considered in appraising the value of the property, but he allowed nothing yond the ends of the level. This was adversely criticised. However, among e reasons prompting a conservative attitude was the recognition of the fact at many gold and silver veins in that region turned into poor zinc-bearing les at a short distance below the limit of visible oxidation. In the sequel he s proved to be right. When, later on, the mine underwent extensive developnt it was found that at 45 ft. below the lowest level the ore became poor in ld and silver, but heavily charged with zinc blende, while at the same time e lowest level ran out of the ore-body within a few feet at both ends. In this gard it is a curious fact how often good miners, especially if they are selling a ine, stop their explorations at the proper psychological moment.

The great copper region around Butte, Mont., exemplifies another aspect of the quiry. Very extensive exploration, prompted by the extreme richness of the les, has permitted of the accumulation of evidence, which proves conclusively at the big ore-bodies are the result of a secondary enrichment brought about the leaching of copper by the ground-water and its precipitation upon the

sulphides of the deeper zone. The original vein stone consisted of iron pyrite, copper pyrite and, probably, enargite, while the bonanzas consist of the higher sulphides, bornite, covellite and chalcocite. Experiments have been made[6] in the laboratory which illustrate the formation of chalcocite (copper glance) on pyrite by precipitation from a solution containing copper sulphate, such as would be the product of oxidation through the agency of the ground-water. As a result of such reactions the outcrops are poor in copper and silver, because these have been leached out; the silver appears at a comparatively shallow depth (300 or 400 ft. below the surface) so as to form a zone of maximum enrichment in that metal, while the copper has been deposited deeper still, so as to form the magnificent masses of high-percentage ores which have made Butte so productive. Below these come the first-formed ores, chiefly pyrite with a little copper pyrite, without the higher copper sulphides which have enriched the overlying zone. While, therefore, the lower limit of the horizon of secondary enrichment has been passed through in some of the mines, it must be added that in others the rich sulphides extend to a depth of over 2,000 ft. from the surface, so that the effects

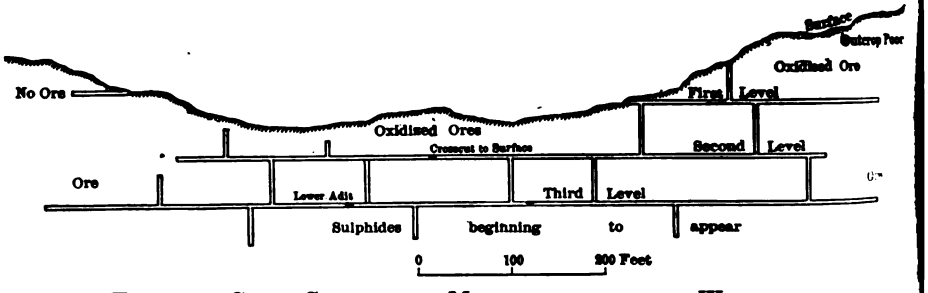


FIG. 16.—CROSS-SECTION OF MINE, SHOWING THE WORKINGS.

of the ground-water circulation continue to a profundity quite exceptional in the experience of mining. This may be due to the intensity of the fracturing which followed the deposition of the earlier sulphides, and it may be partly a result from the open character of the lode channels which has permitted of the far-reaching penetration of the ground-water, but, whatever the cause, it renders the problem of ore-occurrence at Butte quite exceptional, particularly when compared to cases such as the one quoted in the preceding instance, in Fig. 15. A novice who has sampled the shallow workings of a young mine in a region such as Butte would be likely to be misled by the low percentage of copper, and therefore enunciate an unfavorable opinion, whereas one who recognized the effects of ground-water leaching and was guided possibly by a knowledge of the changes encountered at greater depth, in a neighboring mine, would make quite a different inference. Under other circumstances in another region the occurrence of the higher sulphides, such as covellite and chalcocite, would suggest secondary enrichment and warn the engineer against counting upon a persistence of conditions which are frequently quite local.

Considerations such as these suggest very forcibly that keen observation and

[6] "The Synthesis of Chalcocite," by H. V. Winchell, *Engineering and Mining Journal*, May 23, 1903.

ide experience are required for the appraisement of the potentialities of a rospect.

Conclusion.—This discussion of the subject has emphasized one great factor n work of this kind, and that is—the personal equation. No two men set to work n exactly the same way, and no two men make exactly the same deductions from complicated series of data. My views on the subject are those based upon my wn experience—hence the inevitable limitations of my presentation of it. For his reason also I have omitted to refer to the literature which deals with sampling nd estimates of ore because it would have extended this contribution to uncom-ortable length had I taken up the other aspects of the inquiry as discussed by ther men. Herein lies my excuse and my apology to the Institution of Mining nd Metallurgy, to Messrs. J. D. Kendall, E. B. Kirby, A. G. Charleton, W. Wy-ergh, G. A. Denny, S. J. Truscott, D. W. Brunton, W. McDermott and other uthoritative writers on the same subject.

The conclusion of the whole matter is sufficiently obvious—so obvious as to eed but little further insistence. If the discussion of the methods to be applied n the sampling and estimation of ore has served to accentuate the difficulties to e encountered in the diagnosis of a mine, then it will have fulfilled one of the urposes of this contribution. *"Chi va piano, va sano."* Extreme care is neces-ary at every stage of the work—care and experience, the experience born of wide nowledge and practical work without which a man in a mine is no better than he proverbial bull in a china shop, with a strong suggestion of a coming smash!

The old hands—the engineers who have sampled mines from China to Peru—o not need my maxims to guide them. They have lost the cheerful confidence f their apprentice days and are saturated with the experience of difficulty and oubt which have been frankly faced on a hundred occasions. To the youngster, ho still has to receive his first fall and to realize that few data are absolutely rtain, also that data carelessly obtained are inevitably uncertain—to him this alysis of methods of work will, it is earnestly hoped, serve as a red flag of warn-g. To the general reader, who is usually more in sympathy with the pains of e unfortunate investor in mines than he is with the causes which may vitiate od advice from the expert, to him these *obiter dicta* will, I trust, suggest forcibly at good advice is hard to get and expensive—yet cheap, indeed, compared to e costly experience of entrusting onerous professional duties to the inefficient.

E MINING STOCK EXCHANGES IN 1902.

es on the following pages give a résumé of the business done during ar on the leading exchanges of the United States and Europe, and ds paid and assessments levied by the principal mining companies. year was less eventful than 1901, the conditions on the whole were sfactory for the mining, as well as the other industries.

THE BOSTON MINING STOCK MARKET IN 1902.

per mining shares show a remarkable shrinkage in value from the of the preceding year, and there has been also a decided falling off in ution of dividends. Of the Lake Superior mines only three paid luring 1902, the aggregate distribution being $3,440,000 or less than ie amount paid in 1901 by six companies. The most noticeable the exchange has been the Calumet & Hecla, which reached the low 420 per share, as compared with the high price for the year of $650. ted Copper shares fluctuated from $78·87 to $52·12, Osceola from ·50, and Tamarack from $276 to $140; Quincy sold down from $140 ie lowest price in four years. Wolverine was an exception in that its ved an upward tendency and reached the highest quotations near the e year. This stock fluctuated from $61 to $42 per share. Mohawk from $27 to $49, but later declined to $40. Among the Canadian lt in at Boston, those of the Dominion Coal Co. and the Dominion on Co. were most active. The former rose from $54 to $146, and rose from $25 to $79·87; both declined heavily, however, toward the e year.

THE COLORADO SPRINGS MINING STOCK MARKET IN 1902.

ords show wide fluctuations in some of the leading stocks, such as rtland, Jack Pot and Vindicator, and the general trend of prices was

Elkton fell from the high price of $1·40 to 30c., Portland from 1·80, Jack Pot from 39c. to 8c., and Vindicator from $1·26 to 93c.

							.00	.75	.85	.50	
						31·50	27·63	33·50	28·00	37
						48·00	43·50	63·00	54·00	...
						27·63	23·50	39·75	25·00	32
						10·50	7·88	10·50	9·25	9
						610·00	575·00	600·00	533·00	570
						38·00	15·75	21·75	19·13	20
						29·00	43·50	62·50	48·38	61
						5·50	3·50	3·75	3·25	4
						14·63	12·00	12·50	11·50	12
						21·00	15·00	17·25	12·00	16
						21·00	17·00	19·63	19·50	21
						3·63	2·50	3·00	2·88	3
						13·25	10·50	12·50	10·25	18
						38·00	33·00	38·00	34·50	44
						4·75	4·00	4·00	2·63	4
						1·75	1·25	1·50	.....	1
						4·50	3·50	4·00	3·50	3
						30·00	18·25	23·75	17·50	29
						75·75	58·50	64·00	60·00	63
						32·75	28·00	29·00	24·75	31
						4·00	3·50	4·00	3·50	5
						141·00	130·00	130·00	125·00	135
						3·25	1·88	2·38	2·25	2
						4·00	2·75	3·50	2·75	3
						230·00	175·00	180·00	170·00	185
						2·00	1·50	2·00	1·50	1
						14·25	10·75			
						108·00	85·00	175·00	100·00	100
						18·50	13·25	14·75	12·63	14
						25·00	21·25	25·00	22·00	33
						6·75	5·25	6·00	4·75	4
						2·00	1·25	2·50	1·50	3
						56·00	50·50	56·00	52·00	56
						1·25	1·00	1·50	1·00	1
						·70	·45	·50	·25	
						2·00	1·00	2·00	1·75	2
						41·00	18·00	49·00	40·00	46
						4·50	3·75	4·25	3·50	4
						3·75	1·50	3·38	2·38	3
						·50		·50		
						19·38	17·50	22·75	18·13	21
						13·50	9·00	14·25	12·00	12
						3·75	2·38	4·00	3·00	4

NG STOCKS AT BOSTON DURING 1902.—*Continued.*

	·st.				September.		October.		November.		December.		Sales. No. of Shares.
					'I.	L.	H.	L.	H.	L.	H.	L.	
						.25	$22·00	$18·25	$21·00	$14·75	$15·00	$12.25	59,995
						2·00	2·75	2·13	2·88	2·25	2·63	2·00	94,990
						63·28	67·25	62·00	65·75	58·13	59·63	52·00	758,757
					.5	25·50	25·50	25·00	25·00	21·00	23·00	21·00	9,891
					5·00	4·50	5·00	4·50	4·75	4·00	4·50	3·50	116,613
					.....	.....	.....	.....	·75	·60	·50	·38	4,070
					.....	.....	·20	.....	·22	·20	.....	.....	150
				25·00	28·00	25·00	26·00	21·00	27·00	22·00	7·63	6·00	24,119
													47,084
			54·50	29·50	32·75	29·50	39·50	27·00	59·25	24·00	29·38	26·00	99,650
			7·88	6·00	6·00	5·50	.....	.....	7·00	5·00	6·00	.....	8,425
		5·00	555·00	526·00	565·00	450·00	559·00	505·00	510·00	455·00	476·00	420·00	4,357
		17·50	19·00	17·25	19·50	15·50	19·25	16·00	19·63	15·13	17·00	15·00	260,487
	.38	52·75	59·88	56·00	60·75	54·50	60·50	54·50	65·25	50·00	57·75	57·25	589,165
	4·13	2·75	3·50	2·63	3·13	2·50	3·00	2·50	3·00	2·00	2·13	1·75	87,317
	15·25	10·50	12·00	10·00	11·00	10·00	10·50	9·63	10·00	7·50	9·00	7·50	18,344
...	15·75	12·00	15·00	11·63	15·25	13·00	14·00	13·00	14·00	9·00	12·00	9·00	43,088
.....	18·88	17·75	17·88	17·00	18·25	15·25	16·38	14·25	15·00	13·50	14·13	12·50	112,645
	2·50	2·00	2·25	.....	2·38	1·38	2·00	1·50	1·75	1·50	1·75	1·50	28,719
.....	12·00	11·25	12·00	11·25	12·00	10·13	11·00	9·50	10·00	7·00	7·50	7·00	38,645
.....	45·50	40·75	47·50	43·00	49·00	45·00	47·38	45·00	47·00	37·50	39·00	36·00	120,238
& Boston (*i*)...	2·50	2·00	3·88	2·38	3·63	2·63	3·75	2·38	3·00	2·88	3·50	2·38	342,584
b).....					1·50	.....							2,800
y (*b*).....	3·00	2·25	3·00	2·50	3·50	2·00	2·50	2·00	2·00	1·13	1·25	1·35	17,101
ion (*c*)	20·00	18·00	19·50	17·00	19·25	16·00	18·00	16·00	17·00	14·75	16·50	14·25	68,864
).....	62·75	58·00	60·00	55·00	62·00	56·00	59·00	56·00	59·00	47·50	54·00	50·00	98,979
.....	30·00	26·75	28·50	26·00	28·50	25·00	26·50	25·00	26·00	21·00	26·00	22·00	26,392
on. (*b*).....	5·00	4·25	5·00	4·00	5·00	4·50	4·88	4·00	4·75	3·75	4·00	3·25	16,820
.....	137·00	130·00	130·00	125·00	135·00	125·00	130·00	125·00	200·00	105·00	109·00	100·00	5,119
und (*b*).....	3·00	1·75	3·00	2·50	3·00	2·50	2·50	1·75	2·38	1·25	3·00	1·50	20,318
f).....	2·50	1·75	2·38	1·75	2·00	1·50	2·00	1·50	1·88	1·50	1·63	1·50	69,484
a).....	13·50	12·50	12·50	9·00	11·50	9·00	10·00	9·00	9·75	8·00	.....	.....	33,486
(*b*).....	182·00	175·00	180·00	171·00	180·00	165·00	175·00	162·00	160·00	146·00	145·00	140·00	14,396
(*b*).....	3·25	2·75	3·00	2·50	2·75	2·00	2·00	1·50	1·50	1·00	1·00	·50	7,292
(*k*)	18·50	16·25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,984
ain (*b*).....	95·00	.....	.....	.....	90·00	87·50	.....	.....	95·00	92·00	93·00	91·00	71,455
.....	12·75	11·13	12·50	11·00	12·25	10·50	12·25	10·00	11·00	8·50	9·00	8·00	68,719
.....	35·00	34·35	35·00	34·75	22·38	20·75	.....	.....	32·88	19·00	30·50	30·00	10,214
(*h*).....	22·00	19·00	21·50	20·25	23·50	20·50	22·25	15·00	22·00	14·00	26·00	22·38	106,198
.....	6·38	5·25	6·25	5·75	6·00	3·13	7·00	3·13	6·75	3·00	5·00	4·00	54,642
.....	·25	.....	·50	·30	·25	.....	.....	.....	.....	.....	·25	.....	975
on (*b*).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
).....	5·25	4·00	6·00	4·25	5·50	4·00	4·25	3·75	4·00	3·00	4·75	3·00	57,997
(*b*).....	60·00	54·50	60·00	57·00	61·50	58·00	60·00	58·00	60·00	57·25	60·00	57·50	24,197
e (*b*).....	1·75	1·00	.....	.....	1·50	1·00	1·00	.....	1·00	.....	6·00	·75	15,342
old :													
.....	·35	.....	1·00	·60	·60	·50	·60	·50	1·75	.....	·30	.....	57,099
ur (*h*).....	2·25	2·00	2·50	2·00	2·93	1·96	2·50	1·64	2·00	1·75	1·88	1·75	176,890
(*h*).....	56·00	48·00	54·00	50·00	53·13	49·50	50·75	49·00	50·50	42·00	39·00	34·00	47,367
o (*l*).....	4·00	2·88	4·25	3·50	4·75	3·25	3·75	2·25	4·50	3·00	3·50	2·50	130,543
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50
redging.....	3·00	.....	2·75	2·25	2·50	2·25	.....	.....	2·13	1·50	.....	.....	22,165
(*e*).....	.....	.....	.....	.....	8·00	6·00	9·00	7·00	.....	.....	.....	.....	1,070
bel (*e*).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,570
tes (*h*).....	22·00	19·00	21·25	20·25	22·88	20·75	.....	.....	21·75	18·25	22·75	20·13	339,990
Zinc :													
& Sm. (*g*).....	16·00	11·00	14·50	12·75	12·09	12·00	12·00	11·00	12·00	10·00	7·00	.....	32,985
d (*a*) (old)....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,288
d (new).....	15·00	.....	.....	.....	.....	.....	16·88	16·00	16·88	16·00	16·50	.....	364
llaneous :													
.....	·80	·40	.....	.....	.....	.....	.....	.....	·60	.....	.....	.....	3,250
d).....	·80	·75	1·00	·65	·95	·75	·80	·60	·75	·66	·75	·58	22,931
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,200
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
.....	.....	.....	·50	.....	.....	.....	.....	.....	.....	.....	.....	.....	448
).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(*m*).....	8·00	.....	8·00	7·50	7·50	7·25	.....	.....	.....	.....	7·00	6·25	6,291
Coal (*f*).....	37·50	132·50	148·75	135·00	146·50	126·00	135·25	124·00	133·00	125·00	129·50	126·00	188,677
Coal, pref. (*f*)	15·00	114·50	116·50	115·00	117·00	116·50	117·00	115·00	117·00	115·00	119·50	117·50	10,939
L. & S (*f*).....	68·00	52·00	79·88	61·00	78·00	60·00	71·50	50·00	61·50	52 50	59·00	53·00	574,411
& Coke (*a*)...	3·75	.....	3·50	2·88	5·63	3·25	6·00	5·13	5·50	5·00	5·00	.....	18,514
l Gas & Coke..	4·75	3·00	6·00	4·50	5·50	4·00	9·50	.....	8·50	.....	.....	.....	84,688
(*e*)..	8·75	8·50	9·75	9·00	9·75	9·00	.....	.....	.....	.....	9·00	.....	1,910
tes Oil (*m*)....	18·50	15·00	17·63	16·25	17·00	14·00	16·00	14·00	21·00	13·00	14·63	13·00	199,412
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,266,094

ntana; (*b*) Michigan; (*c*) Arizona; (*d*) Colorado; (*e*) California; (*f*) Nova Scotia; (*g*) Missouri; (*h*) Utah; Columbia; (*j*) New Mexico; (*k*) Tennessee; (*l*) Mexico; (*m*) West Virginia.

the average of the level is only 3.5 ft. of 4-dwt. ore; this is doubtless the reason why the drift was not extended to the limit of the shoot. A raise put up from this level is in *poor ground* until within 50 ft. of No. 4; then marked improvement sets in. This is confirmed by the results from the No. 4 adit, which gives an average of 3 ft. of 10-dwt. ore. This good mill stuff, however, does not extend much above the level, as is proved by a raise, which gets into poor ground.

These data are perplexing and indicate an alternation of values which renders any estimate very hazardous. When, however, the geological structure is investigated, there is found to be a relation, between values and structure, which illuminates the entire problem. In Fig. 11 there is given a section, on the plane of the vein, which exhibits the position of the series of layers through which the vein cuts. This helps to explain the results shown in Fig. 10. The zones of enrichment penetrated by adits No. 1 and No. 4 coincide with two layers of close-textured tuff, or fine-grained breccia, laid down during the intermittent violence of volcanic

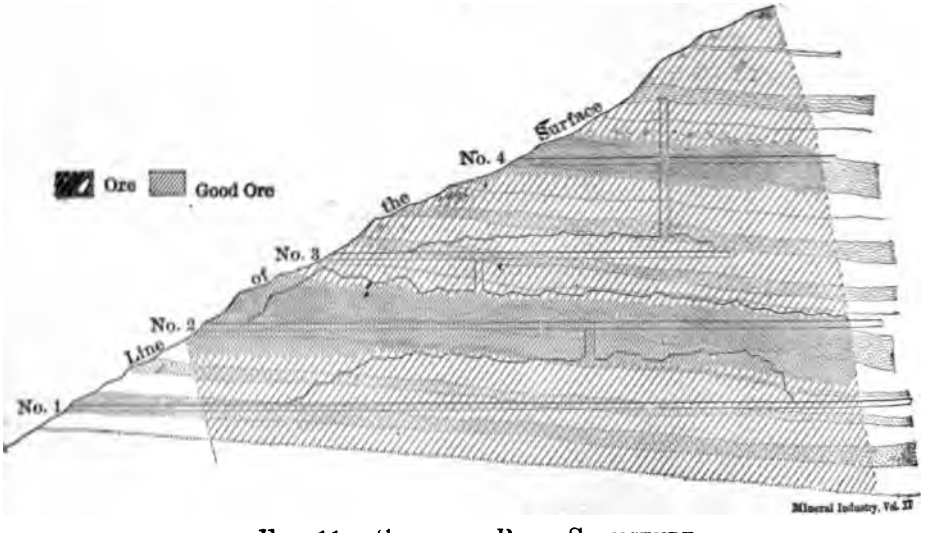


FIG. 11.—SHOWING ROCK STRUCTURE.

eruption. The intermediate, overlying, and underlying beds of breccia are coarse, and, for some reason which does not concern the present inquiry, they are less favorable to ore-deposition than the occasional layers of tuff.

In this instance the evidence was very clear; in other mines situated in the same region it is not practicable, on account of the decomposition of the enclosing country, to establish the relationship so clearly, but it is a matter of experience that notable variation in both the width and value of the lodes does occur in a similar nearly horizontal direction. The understanding of it is, therefore, a clue to many apparent vagaries in the distribution of rich ore.

In the case of a mine which contains several ore-bodies there are many useful suggestions to be obtained from a comparison of their characteristics. Careful investigation will lead sometimes to the detection of peculiarities applicable to the general occurrence of ore in that particular mine. The longitudinal section of the

to warrant the close study given by a general to the map of the region which is the scene of his campaign. Stope-maps are not always correct, sometimes are incorrect to a very misleading degree. A few measurements, at least, are to be made to test this point, and occasionally, when the general accuracy is obvious warrants a doubt, it is a good precaution to make one's own map by one's own personality, or by engaging the services of a reliable surveyor. Mine forms are so diverse that it is impossible to give a typical illustration. By way of suggestion I will append an example of inferences derived from a study of the old workings of a mine. It is a small mine, for, after all, most perplexing of problems is a prospect, and it is found in practice that greatest mistakes and the exercise of the keenest judgment are alike ex-

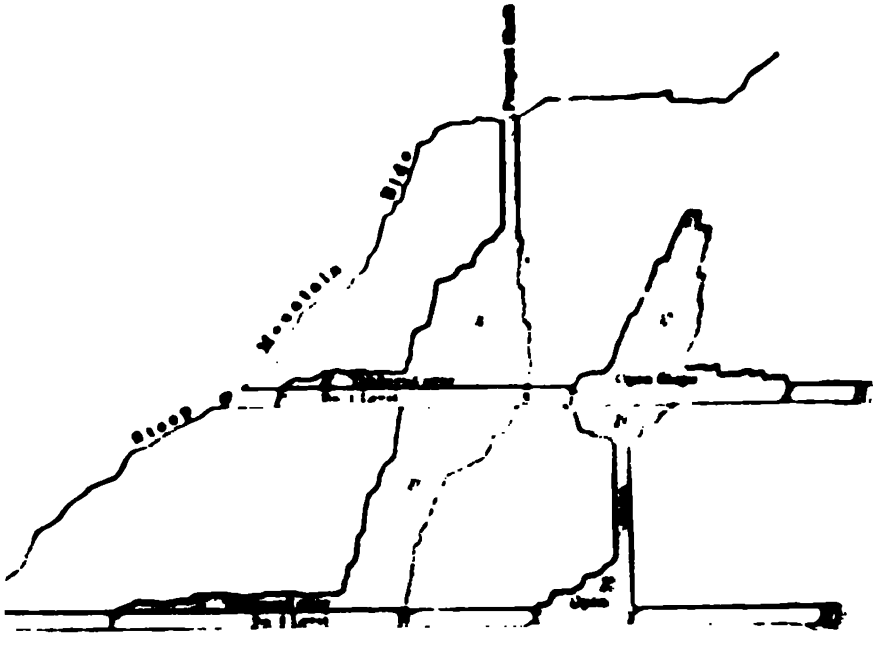


Fig. 13.—Section of a Mine showing the Ore in Chimneys

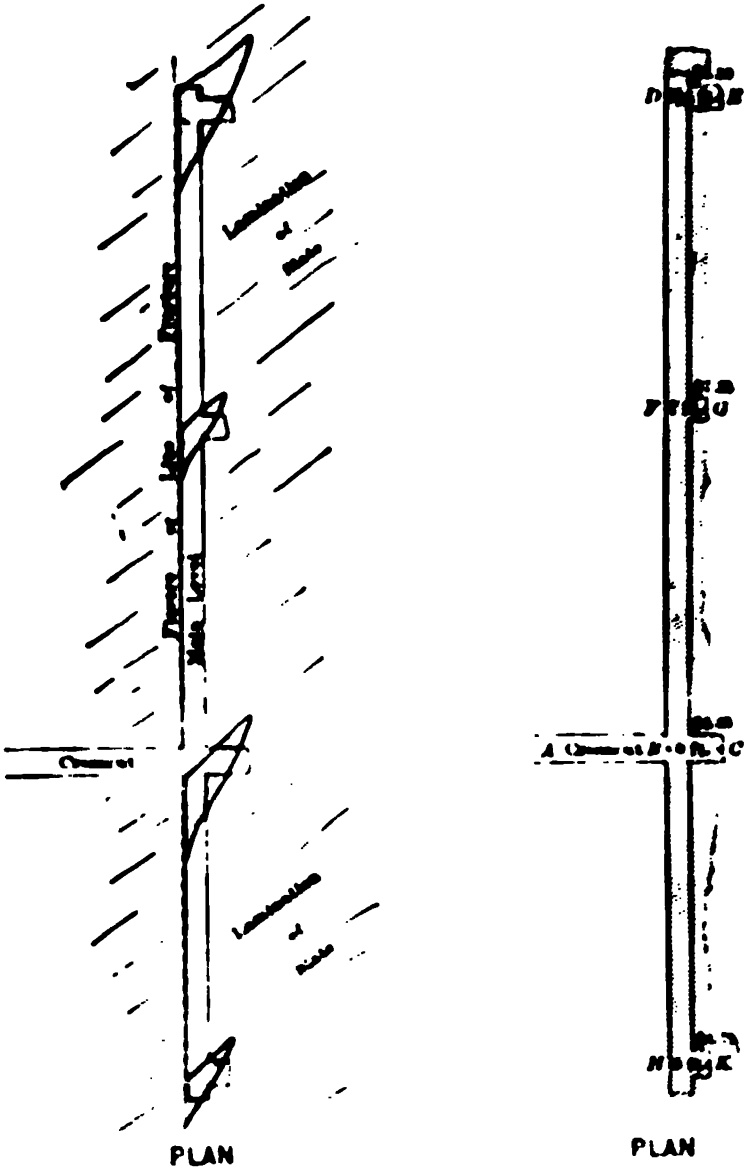
of the appraising of the ... an orebody just ... there ... of the property ... I ... of two adits, ... together with ... upper level ... a raise connecting ... A V). The prob- ... what we ... a good ... of ore ... to ... (II W) ... In ... ore ... of ... ore ... of ...

... not always ... have ... ore ... the ... and they are carefully ... so as to ... examination

Sometimes this is intentional. In the case cited the upper level appears to carry one continuous body of ore from *P* to the breast at *H*, with a small comparatively barren interval *S T*. The timbering obscures the fact that the first half of the stope *P S* is only a cutting-out stope, which was worked for the purpose of testing a low-grade portion of the vein; the same applies to more than two-thirds of the stope *V W*, at the lower level. Similarly, while the timbering between *T* and *Z* indicates a good length of stope, as a matter of fact the innermost half of this is little more than a "cutting-out" stope in comparatively poor ground. The truth is, the ore-body *A B* did not go to surface, having been first cut by the discovery shaft at 70 ft. down; it is a very short body of ore, almost a chimney, and it diminishes in approaching the lower level: further, the ore-body *C D* is still less persistent; it is a narrow, short lens which does not hold out to the lower level, nor does it go up more than half way to surface, but it makes a sort of spurious connection, by means of the raise, with another patch of ore, *E*, on the second level. In practice, such workings as these are largely inaccessible, and usually dangerous; as a consequence, the statements of an inaccurate superintendent, who desires to serve his employer by putting things in the most favorable light, are apt to carry more weight than they should, so that, with the usual desire for quick decision on the part of both the vendor and the vendee, the engineer may be pushed to a conclusion which the actual facts do not warrant. It may seem to one who has missed the essential character of these ore-bodies, through the failure to examine the old workings, that the good width of rich ore at *H* and at *M* indicates the beginnings of a big body of ore which persists, at least, from one level to the other, but, to another man, who has carefully studied the old workings, it is evident that the probabilities point merely to another narrow lens of uncertain extent. The moral is, do not allow yourself to be hurried into an opinion by either party to the transaction, and beware of workings which are stated to be inaccessible, because such inaccessibility may have a purpose.

Another illustration will emphasize the warning conveyed in the last sentence. In Fig. 13 is represented the single level of a Californian mine which is reached by the western cross-cut shown to the left of the drawing. The level is 450 ft. long; owing to the fact that the country is a soft, black slate the ground is very heavy and the level is closely timbered throughout, permitting of only occasional glimpses of ore at the points where short cross-cuts have been run out eastward. At these places, *D E*, *F G*, *B C* and *H K*, the lode is plainly visible and exhibits from 6 to 8 ft. of fairly uniform quartz carrying an average of from 6 to 7 dwt. gold, in a district where working costs are about $3 per ton. After sampling these cross-cuts, examining the little there was to be seen, and finding that the ground really seemed heavy enough to justify the close timbering over the level, the engineer came to the conclusion that he was dealing with one of those persistent ore-bodies not uncommon in that part of California, and he estimated the ore to have the continuity exhibited by the cross-hatching in the drawing. However, he had wholly misunderstood the real character of the ore-occurrence, as Fig. 14 will indicate. The close timbering was not necessary in order to sustain the ground alone; it was an excuse for obscuring certain facts. The quartz exposed by the several cross-cuts belonged to a number of small lenses. These abutted

...ment the "fissure," or main line of fracture, which constituted the supposed ... the lenses were short-lived and lay with their longer axis parallel to the



...m 13 and 14.—Showing Lode Structure ... Methods of Sampling

...of slate, the beds at D E on's lateral as far as two sets of timbers, that ...d died out at 60 ft., and that at B C "petered out" at 40 ft. above the level.

while the last one, *H K*, went up as a narrow body for a distance of 100 ft. Compare Fig. 10 with Fig. 13 and quote Hamlet's comment on his own portrayal of his mother's successive husbands. This incident did not befall a tyro, but an old campaigner, who was caught by his own carelessness under circumstances from which only the greatest wariness could have saved him.

Misconceptions concerning the conditions contributory to the localization of ore shoots and the consequent mistaken ideas as to the future possibilities of a mine have often arisen from a misunderstanding of vein intersections. In the case of a well-known mine in southwestern Colorado, a length of 2,700 ft. of ore had been opened up by an upper level, and stopes, which had worked out most of the ore except at one end, had proved that it persisted to the surface, an average distance of 150 ft. above this upper level. In the meantime two winzes had demonstrated the apparent downward continuance of the ore-body. A longitudinal section of these workings is shown in Fig. 14. In the examination of the mine by several distinguished mining engineers, it was assumed that the winzes, one of which was 58 ft., and the other 143 ft. deep, proved the continuity of the ore-body to an extent sufficient to warrant a price for the property

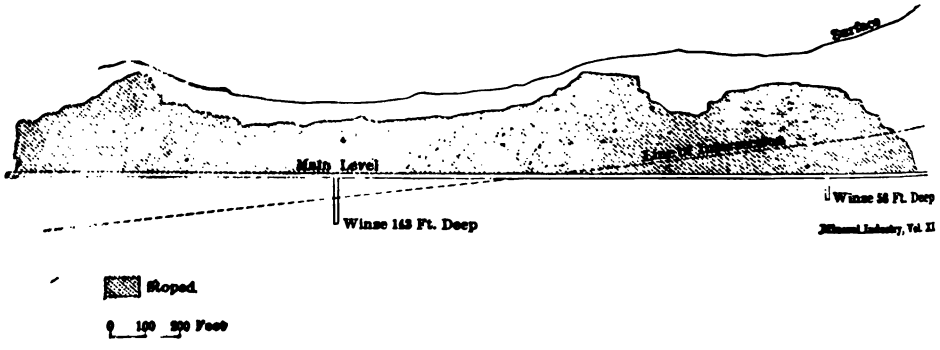


FIG. 15.—LONGITUDINAL SECTION.

which was a good deal in excess of the net profits to be won from the ground as measured to the bottom of the winzes. In the sequel it was found, after the mine had been purchased and when deeper workings had explored the lower horizon, that the ore-body owed its existence, and certainly its shape and position, to the intersection with another lode. This made a "scissors crossing," the hinge of which was a line, dipping west at an angle of 7° 30′. The ore-body reached from this line to the surface, while downward it extended about a hundred feet or so. Other scattered smaller bodies of ore were, it is true, encountered, but the main ore-body of the mine, upon which its value was based, extended only about a hundred feet below the broken line shown across the longitudinal section in Fig. 15. Such an instance as this proves the need for deciphering the conditions which have affected the distribution of ore. The crossing referred to was visible in the stopes at the east end, but only to an inquiring observer who suspected some eccentricity of lode structure.

Collateral Evidence.—Of all the collateral evidence likely to aid the engineer in a correct diagnosis of the condition of the mine he is examining, none is so

sulphides of the deeper zone. The original vein stone consisted of iron pyrite, copper pyrite and, probably, enargite, while the bonanzas consist of the higher sulphides, bornite, covellite and chalcocite. Experiments have been made[4] in the laboratory which illustrate the formation of chalcocite (copper glance) on pyrite by precipitation from a solution containing copper sulphate, such as would be the product of oxidation through the agency of the ground-water. As a result of such reactions the outcrops are poor in copper and silver, because these have been leached out; the silver appears at a comparatively shallow depth (300 or 400 ft. below the surface) so as to form a zone of maximum enrichment in that metal, while the copper has been deposited deeper still, so as to form the magnificent masses of high-percentage ores which have made Butte so productive. Below these come the first-formed ores, chiefly pyrite with a little copper pyrite, without the higher copper sulphides which have enriched the overlying zone. While, therefore, the lower limit of the horizon of secondary enrichment has been passed through in some of the mines, it must be added that in others the rich sulphides extend to a depth of over 2,000 ft. from the surface, so that the effects

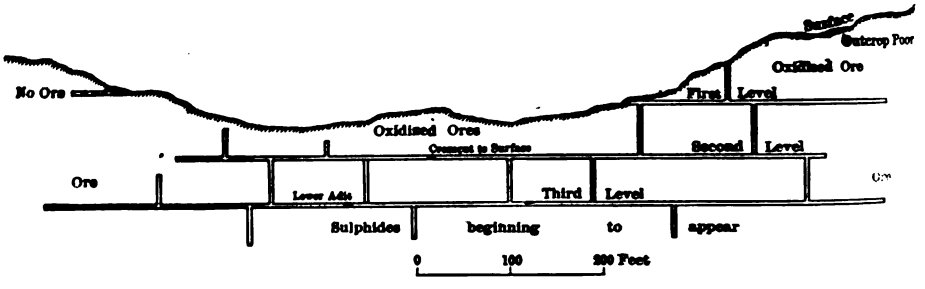


FIG. 16.—CROSS-SECTION OF MINE, SHOWING THE WORKINGS.

of the ground-water circulation continue to a profundity quite exceptional in the experience of mining. This may be due to the intensity of the fracturing which followed the deposition of the earlier sulphides, and it may be partly a result from the open character of the lode channels which has permitted of the far-reaching penetration of the ground-water, but, whatever the cause, it renders the problem of ore-occurrence at Butte quite exceptional, particularly when compared to cases such as the one quoted in the preceding instance, in Fig. 15. A novice who has sampled the shallow workings of a young mine in a region such as Butte would be likely to be misled by the low percentage of copper, and therefore enunciate an unfavorable opinion, whereas one who recognized the effects of ground-water leaching and was guided possibly by a knowledge of the changes encountered at greater depth, in a neighboring mine, would make quite a different inference. Under other circumstances in another region the occurrence of the higher sulphides, such as covellite and chalcocite, would suggest secondary enrichment and warn the engineer against counting upon a persistence of conditions which are frequently quite local.

Considerations such as these suggest very forcibly that keen observation and

[4] "The Synthesis of Chalcocite," by H. V. Winchell, Engineering and Mining Journal, May 8, 1909.

experience are required for the appraisement of the potentialities of a mine

a reason. This discussion of the subject has emphasized one great factor of the kind, and that is the personal equation. No two men set to work alike the same way, and no two men make exactly the same deductions from separated series of data. My views on the subject are those based upon my experience, hence the inevitable limitations of my presentation of it. For reasons also I have omitted to refer to the literature which deals with sampling estimates of ore because it would have extended this contribution to unseemly length had I taken up the other aspects of the inquiry as discussed by others. Herein lies my excuse and my apology to the Institution of Mining Metallurgy, to Messrs J. D. Kendall, E. B. Kirby, A. G. Charleton, W. Wyatt, A. Evans, S. J. Truscott, D. W. Brunton, W. McDermott and other relative writers on the same subject.

A conclusion of the whole matter is sufficiently obvious—an obviousness as to but little further moment. If the discussion of the methods to be applied to sampling and estimation of ore has served to accentuate the difficulties to be encountered in the diagnosis of a mine, then it will have fulfilled one of the aims of this contribution. If by its means to aim. Extreme care to prove at every stage of the work, care and experience, the experience born of wide hedge and practical work without which a man in a mine is no better than a bull in a china shop with a strong suggestion of a coming smash.

To the engineers who have sampled in two from China to Peru—I could not mention to you by them. They have set the basis of confidence and cooperation have and [illegible] the [illegible] of [illegible] and [illegible] have been found [illegible] and [illegible] [illegible] [illegible] of [illegible] to [illegible] [illegible] and [illegible] [illegible] [illegible] are absolutely [illegible] that data carelessly obtained are [illegible] uncertain to him the use of methods of work will [illegible] [illegible] as a red flag of warning.

To the general reader, who is usually more in sympathy with the pains of the estimate investor in mines than he is with the causes which may vitiate advice from the expert, to him these chapters [illegible] will I trust suggest [illegible] that advice is hard to get and expensive, yet cheap, indeed compared to the folly experience of entrusting one's professional duties to the inefficient

THE MINING STOCK EXCHANGES IN 1902.

[illegible] on the following pages give a resume of the business done during past year on the leading exchanges of the United States and Europe, and [illegible] paid and assessments levied by the principal mining companies [illegible] year was less eventful than 1901, the conditions on the whole were [illegible] factors for the mining, as well as the other industries

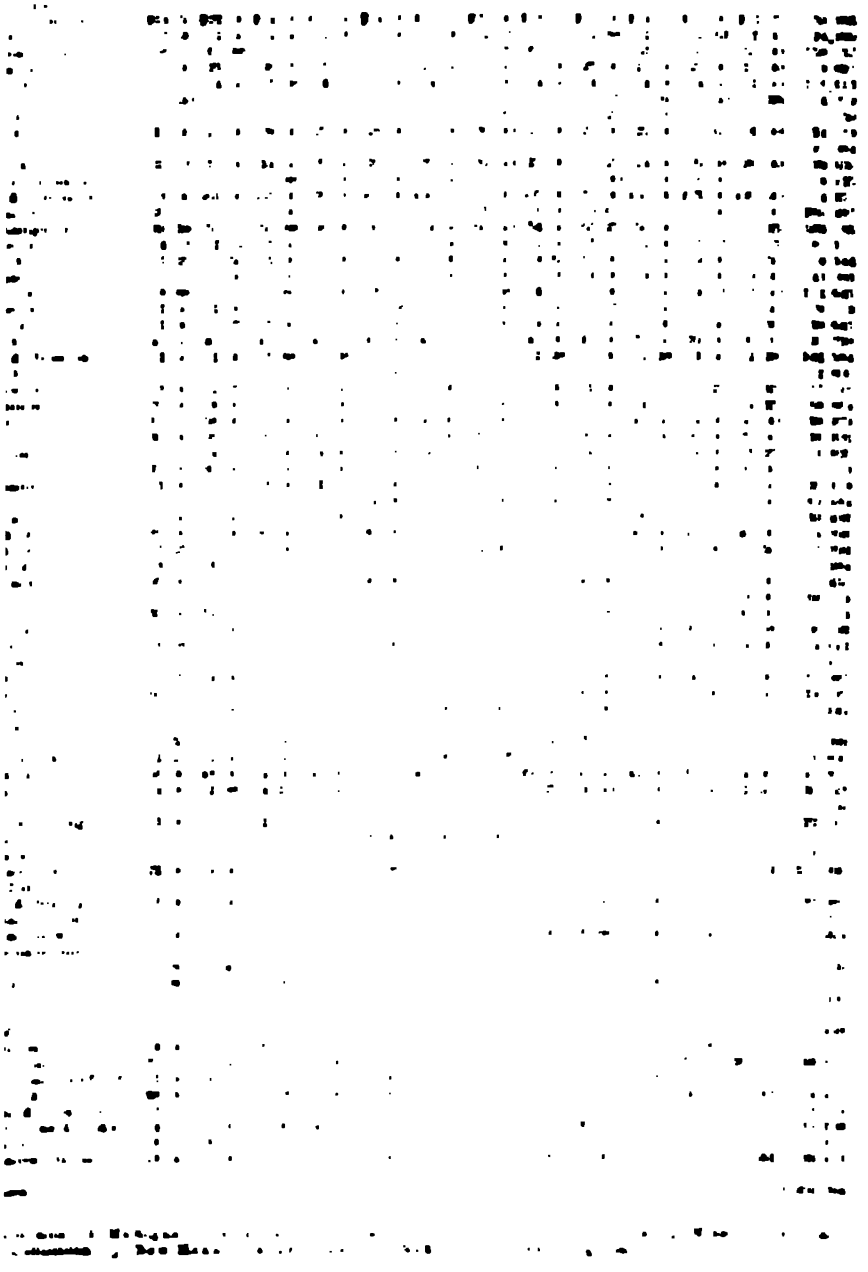
The Boston Mining Stock Market in 1902

[illegible] gratifying showing of a remarkable advance in value from the [illegible] of the preceding year, although there has been a marked falling off in [illegible] of dividends. Of the Lake Superior mines only three paid [illegible] these the aggregate [illegible] less than [illegible] Calumet & Hecla and Atlantic the low [illegible] are compared with the high prices for the year of 1901 [illegible] Quincy from $[illegible] to $[illegible] Tamarack from $[illegible] to $[illegible] Quincy sold down from $[illegible] [illegible] lowest prices in four years. Wolverine was an exception in that its [illegible] an upward tendency and reached the highest point near the [illegible] year. The stock of Osceola from $61 to $[illegible] per share. Mohawk [illegible] from $[illegible] to $[illegible] declined to $[illegible]. Among the Canadian [illegible] at Boston those of the Dominion Coal Co. and the Iron [illegible] A low [illegible] were made [illegible] from $[illegible] to $[illegible] and [illegible] from $[illegible] Atlantic [illegible] Wolverine [illegible] Quincy [illegible] Osceola [illegible] Tamarack [illegible] Mohawk [illegible] Calumet & Hecla [illegible] Dominion Coal [illegible] Iron [illegible]

The Colorado Springs Mining Stock Market in 1902

[illegible] shows much [illegible] of the leading stocks such as [illegible] and Jack Pot [illegible] and the general trend [illegible] was upward. Elkton fell from the high price of $[illegible] to the Portland from $[illegible] Jack Pot from [illegible] and Vindicator from $[illegible]

Name of Company	Par Value	January		February		March		April		May		June	
		H	L	H	L	H	L	H	L	H	L	H	L
Copper													
Anaconda Cop. (b)	25	22 00	21 75	22 00	21 50	21 50	21 00	21 00	20 50	20 50	20 00	20 00	19 50
Bonanza (b)	25	2 75	2 50	2 50	2 25	2 25	2 00	2 00	1 75	1 75	1 50	1 75	1 50
Butte & Boston (b)	25	50 00	47 25	47 50	45 00	47 00	44 25	44 25	41 50	42 00	39 50	40 00	38 00
Calumet & Ariz. (b)	25	80 00	77 00	77 00	74 00	74 00	71 00	71 00	68 00	68 00	65 00	65 00	62 00
Calumet & Hecla (b)	25	700 00	675 00	675 00	650 00	650 00	625 00	625 00	600 00	600 00	575 00	575 00	550 00
Centennial (b)	25	3 00	2 75	2 75	2 50	2 50	2 25	2 25	2 00	2 00	1 75	1 75	1 50
Copper Range (b)	25	61 75	58 00	58 00	54 00	54 00	50 00	50 00	46 00	46 00	42 00	42 00	38 00
Davis-Daly (b)	10	2 75	2 50	2 50	2 25	2 25	2 00	2 00	1 75	1 75	1 50	1 50	1 25
Franklin (b)	25	15 50	14 50	14 50	13 50	14 00	12 00	12 50	11 50	12 00	10 75	11 75	11 00
Isle Royale (b)	25	24 25	23 00	23 00	19 50	21 00	15 00	17 25	12 00	14 00	12 50	13 00	12 00
Mass Cons. (b)	25	19 50	15 38	20 75	17 75	21 00	17 00	19 63	14 38	21 50	17 00	20 25	16 63
Mayflower (b)	25	3 50	3 00	4 25	3 50	4 00	3 50	4 00	3 50	5 00	3 50	4 75	4 00
Michigan (b)	25	14 00	9 25	12 00	11 00	13 25	12 50	12 50	10 25	13 50	9 25	12 50	11 50
Mohawk (b)	25	70 00	67 00	70 00	61 00	70 00	63 00	65 00	58 00	64 00	54 00	63 00	59 75
Montreal & Boston	5	4 25	3 00	4 00	3 00	4 75	4 00	4 00	2 63	4 75	3 63	3 00	2 00
National (b)	25	1 50	1 25	2 75	1 50	1 75	1 25	1 50	.....	1 00	.....	.....	.....
Old Colony (b)	25	3 50	2 75	4 00	3 00	4 50	3 50	4 00	3 50	3 50	2 50	3 00	2 25
Old Dominion (b)	25	24 50	21 00	28 75	21 00	30 00	18 25	25 75	17 50	23 00	17 50	21 25	19 50
Osceola (b)	25	80 00	77 50	80 75	75 00	75 75	58 50	64 00	60 00	63 50	59 50	63 00	59 50
Parrot (b)	10	33 25	28 00	35 00	30 50	32 75	28 00	29 00	24 75	31 00	24 75	31 00	25 50
Phoenix Cop. (b)	25	4 50	4 00	4 25	3 50	4 00	3 50	4 00	3 50	5 00	3 50	4 75	4 00
Quincy (b)	25	140 00	135 00	147 00	140 00	141 00	130 00	130 00	125 00	135 00	125 00	135 00	130 00
Rhode Island (b)	25	3 00	2 00	3 00	2 50	3 25	1 88	2 88	2 25	2 50	2 00	2 25	1 50
Santa Fé (b)	10	4 00	2 50	4 00	2 50	4 00	2 75	3 50	2 75	3 00	1 00	2 88	1 88
Shannon (b)	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tamarack (b)	25	270 00	250 00	281 00	230 00	230 00	175 00	180 00	170 00	185 00	169 50	185 00	175 00
Tecumseh (b)	25	1 75	50	2 00	1 50	2 00	1 50	2 00	1 50	1 75	1 25	3 50	1 50
Tennessee (b)	25	14 00	.....	.....	.....	14 25	10 75	.....	.....	.....	.....	17 75	15 00
Tri Mountain (b)	25	60 00	31 50	125 00	61 00	108 00	95 00	175 00	100 00	100 50	100 00	100 00	95 00
Trinity (c)	25	15 00	12 75	14 75	11 00	18 50	13 25	14 75	12 63	14 25	12 13	13 00	11 75
United (a)	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Utah Con. (b)	5	26 50	21 25	27 25	23 88	25 00	21 25	25 00	22 00	23 00	21 00	22 75	20 00
Victoria (b)	25	5 75	4 38	6 50	5 00	6 75	5 25	6 00	4 75	4 88	4 13	6 38	4 00
Washington (b)	25	1 50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winona (b)	25	2 00	1 00	4 50	1 50	2 00	1 25	2 50	1 50	3 88	1 75	5 75	2 50
Wolverine (b)	25	53 00	42 00	55 00	49 00	56 00	50 50	56 00	52 00	56 00	53 00	56 00	54 25
Wyandotte (b)	25	1 13	75	1 25	75	1 25	1 00	1 50	1 00	1 63	1 00	1 63	1 00
Gold:													
Cochill (f)	10	2 00	70	1 25	45	70	45	50	25	50	45	60	30
Com. Mercur (b)	5	1 88	1 38	2 25	1 50	2 00	1 00	2 00	1 75	2 00	1 38	2 13	1 88
Daly West (b)	20	30 00	25 00	29 00	15 50	41 00	18 00	49 00	40 00	46 50	34 75	50 00	44 50
Guanajuato (b)	5	5 75	4 00	4 75	3 25	4 50	3 75	4 25	3 50	4 25	3 25	3 75	3 50
Merced (c)	15	.....	.....	3 50	2 50	.....	.....	.....	.....	.....	.....	.....	.....
N Amer Dredging	5	.....	.....	2 00	1 75	3 75	1 50	3 88	2 38	3 00	.....	.....	.....
North Star (c)	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Santa Ysabel (c)	5	50	.....	50	.....	50	.....	50	.....	.....	.....	.....	.....
United States (h)	25	17 50	13 25	18 25	16 38	19 38	17 50	22 75	18 13	21 50	20 00	21 00	19 00
Zinc:													
Am Z. L. & Sm (g)	25	11 25	10 00	10 00	9 00	13 50	9 00	14 25	12 00	12 38	10 00	12 25	11 00
Continental (g) old	10	2 00	.....	2 75	2 50	3 75	2 38	4 00	3 00	4 00	3 00	4 00	3 00
Continental (new)	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous:													
Ætna (c)	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bonanza (d)	25	90	75	90	80	1 05	75	90	80	80	75	75	70
Boston (c)	10	2 00	.....	2 13	2 00	2 13	2 00	5 00	3 00	.....	.....	.....	.....
Bresee (d)	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Catalpa (d)	10	50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Central Oil (m)	25	.....	.....	8 00	7 00	7 50	7 00	8 38	6 00	9 00	8 00	8 00	7 50
Dominion Coal (f)	100	64 75	52 50	88 50	63 38	123 00	87 00	146 00	122 25	141 50	110 00	142 00	132 00
Dominion Coal, pref. (f)	100	119 00	116 00	118 50	117 00	119 00	116 00	119 00	118 00	116 00	115 00	118 50	114 50
Dominion I. & S.	100	.....	.....	.....	.....	47 50	40 00	75 00	47 00	68 88	50 00	57 00	51 00
Mont. Coal & Coke (n)	25	4 00	3 50	.....	.....	4 50	2 75	4 00	.....	4 50	4 00	4 00	.....
New England Gas & Coke	100	5 25	5 00	6 75	4 50	7 63	5 00	7 50	3 00	4 13	3 25	4 00	2 25
New Idria (c)	5	.....	.....	.....	.....	8 00	.....	7 50	.....	7 50	.....	8 00	7 00
United States Oil (m)	25	12 00	11 00	13 25	12 00	13 00	11 00	16 00	12 25	18 13	15 00	17 00	14 25
Total sales	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....



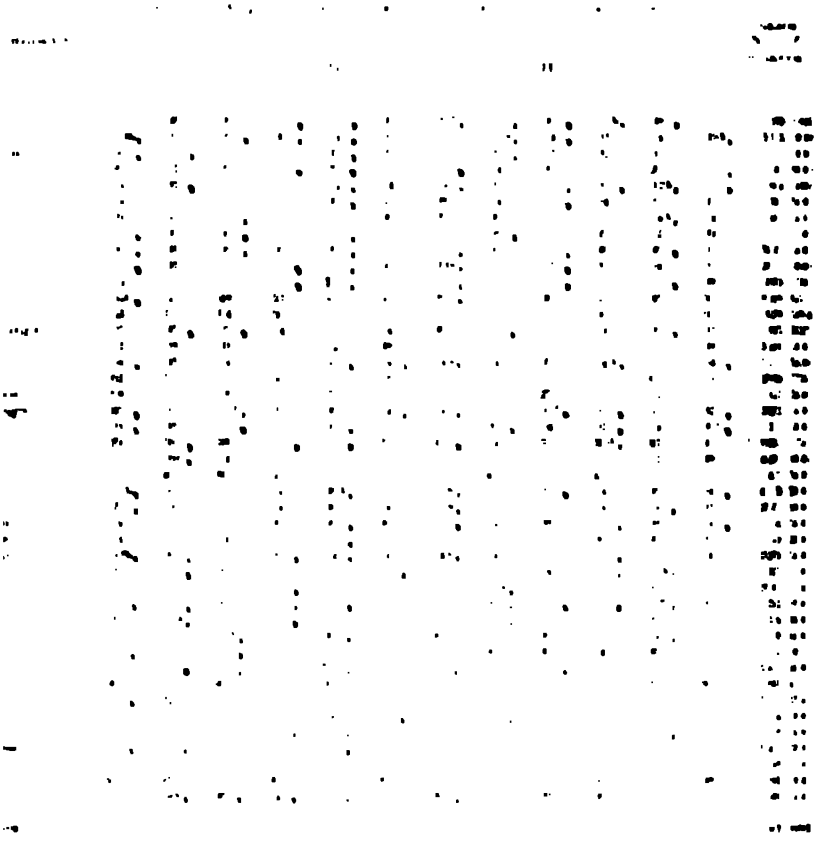
FLUCTUATIONS OF MINING STOCKS AT COLORADO SPRINGS, COLO., DURING 1902.

Name of Company.	Par Value	January		February		March		April.		May		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Acacia	$1·00	·14	·11½	·12	·10½	·11	·10	·10	·09	·11	·10	·10	·09
Alamo	1·00	·14	·12	·13⅝	·10	·08	·08½	·09	·08	·09⅝	·08	·09⅝	·08
American Con.	1·00	·06¾	·06	·06	·06	·06	·06	·06⅝	·06	·06⅝	·06¼	·06⅝	·06
Amazonia	5·00	·25	·20	·30	·27½	·25	·20	·23	·14	·20	·18	·20	·19½
Ben Hur	1·00	·05	·04	·05	·04	·05	·05	·05	·04	·04½	·03	·04½	·03
Black Bear	1·00	·09	·07	·09	·06	·09	·04	·08½	·06	·07	·05	·07	·05
Blue Bell	1·00	·12	·07	·10	·08	·10	·07	·08½	·06	·09	·04	·09	·03
C. K. & N.	1·00	·04	·02	·03⅝	·02¼	·03⅝	·03	·03½	·03	·03	·03⅛	·03⅛	·03
C. O. Con.	1·00	·09	·12	·10	·08½	·09	·07½	·08	·08⅝	·07	·06	·07	·06
Dante	1·00	·03½	·04	·05	·04	·04½	·03½	·03⅝	·04½	·04½	·03½	·04½	·03
Dr. Jack Pot	1·00	·44	·40	·44½	·39	·50	·42½	·48	·31	·40	·19½	·19½	·17½
Elkton	1·00	1·19	1·12½	1·40½	1·27	1·31	1·15	1·30	·75	·74	·57	·65	·61
El Paso	1·00	·60	·55	·65	·56	·58	·53	·55	·43¾	·50	·45	·55	·52½
Fanny Rawlings	1·00	·11	·07	·15	·10	·12	·05	·10	·05	·07	·03	·06	·03½
Findley	1·00	·12	·09	·12	·11	·12	·09	·11	·10	·10½	·08	·09	·08
Gold Dollar	1·00	·06¾	·07	·07	·06	·07	·05	·05⅝	·03	·05	·02	·06¼	·04
Golden Cycle	1·00	·68	·55	·70	·55	·71	·68	·70	·61	·65	·62	·66	·60
Golden Fleece	1·00	·60	·40	·60	·36	·50	·25	·50	·25	·45	·20	·25	·10
Gold Sovereign	1·00	·04	·03	·03¼	·03¼	·04	·02½	·03	·03⅝	·03⅝	·03¼	·03	·03½
Ironclad	·50	·06	·02	·05	·04½	·05	·02	·03½	·02	·03½	·03½	·03½	·03
Isabella	1·00	·35	·27	·33	·27	·25⅝	·23	·27	·24½	·34	·15	·31½	·25
Jack Pot	1·00	·36	·30	·30	·29	·25	·29	·35	·28	·25½	·15	·17	·10
Last Dollar	1·00	·55	·45	·60	·45	·60	·40	·60	·40	·60	·40	·60	·45
Lexington	1·00	·06	·03½	·08	·07½	·06¾	·05½	·06½	·05⅝	·06⅜	·06	·06	·05½
Little Puck	1·00	·06	·04	·07	·05	·06¼	·05	·07	·05	·06	·05	·07	·05
Mollie Gibson	1·00	·20	·16	·20	·14	·14	·10	·14	·10	·15	·10¾	·20	·10
Moon Anchor	1·00	·25	·19	·21	·18	·20	·15	·20	·13¼	·15	·10	·15	·10
Morning Star	1·00	·04	·03	·03⅞	·03¼	·03⅝	·02¼	·03¼	·02	·02⅝	·01¾	·02¾	·01¼
National	1·00	·04	·02	·02¾	·02	·02⅝	·02¼	·03	·01⅞	·02	·01½	·02¼	·01¼
Nellie V.	1·00	·04⅜	·03	·04	·02⅝	·03	·02½	·02⅝	·01⅞	·02⅝	·01½	·02⅝	·01
New Haven	1·00	·05	·03⅞	·04	·03¼	·04¼	·02	·04	·03⅛	·03¼	·02¾	·04	·03½
Pappoose	1·00	·03	·02	·03	·01	·04	·01	·03½	·02	·02	·01	·02½	·01
Pharmacist	1·00	·06	·04⅞	·07	·04¼	·04⅞	·03½	·04¼	·04	·04¼	·03	·04	·03½
Pinnacle	1·00	·09	·07	·08	·06	·07	·05	·07	·05	·06½	·05	·07½	·05½
Pointer	1·00	·04	·03	·03⅝	·03	·04	·03½	·03	·02⅝	·02¾	·02½	·03¼	·02
Portland	1·00	2·90	2·10	2·70	2·57	2·60	2·35	2·05	1·96	1·92	1·75	2·00	1·75
Prince Albert	1·00	·04	·03½	·04	·02⅞	·03½	·02	·03	·02½	·03⅜	·03	·02⅝	·02
Republic	1·00	·04	·03	·03½	·02	·03	·01	·03	·02	·02½	·01½	·03	·01½
Ros Maud	1·00	·07	·05	·05	·04¼	·04½	·03	·05	·03½	·03½	·01½	·03¾	·01
Sunset Eclipse	1·00	·10½	·07½	·12	·08	·13¾	·09	·10⅝	·07	·07⅝	·03	·03¼	·02½
Uncle Sam	1·00	·02¾	·01½	·03	·01⅝	·02	·01	·02	·01	·03	·01	·02½	·01
Vindicator	1·00	1·26	1·19	1·22	1·14	1·20	1·13	1·14	1·01	1·00	·85	·95	·90
Work	1·00	·10	·08⅜	·09½	·06	·08½	·06	·07⅜	·06	·07½	·05	·07	·05½
Total sales													

THE NEW YORK STOCK MARKET IN 1902.

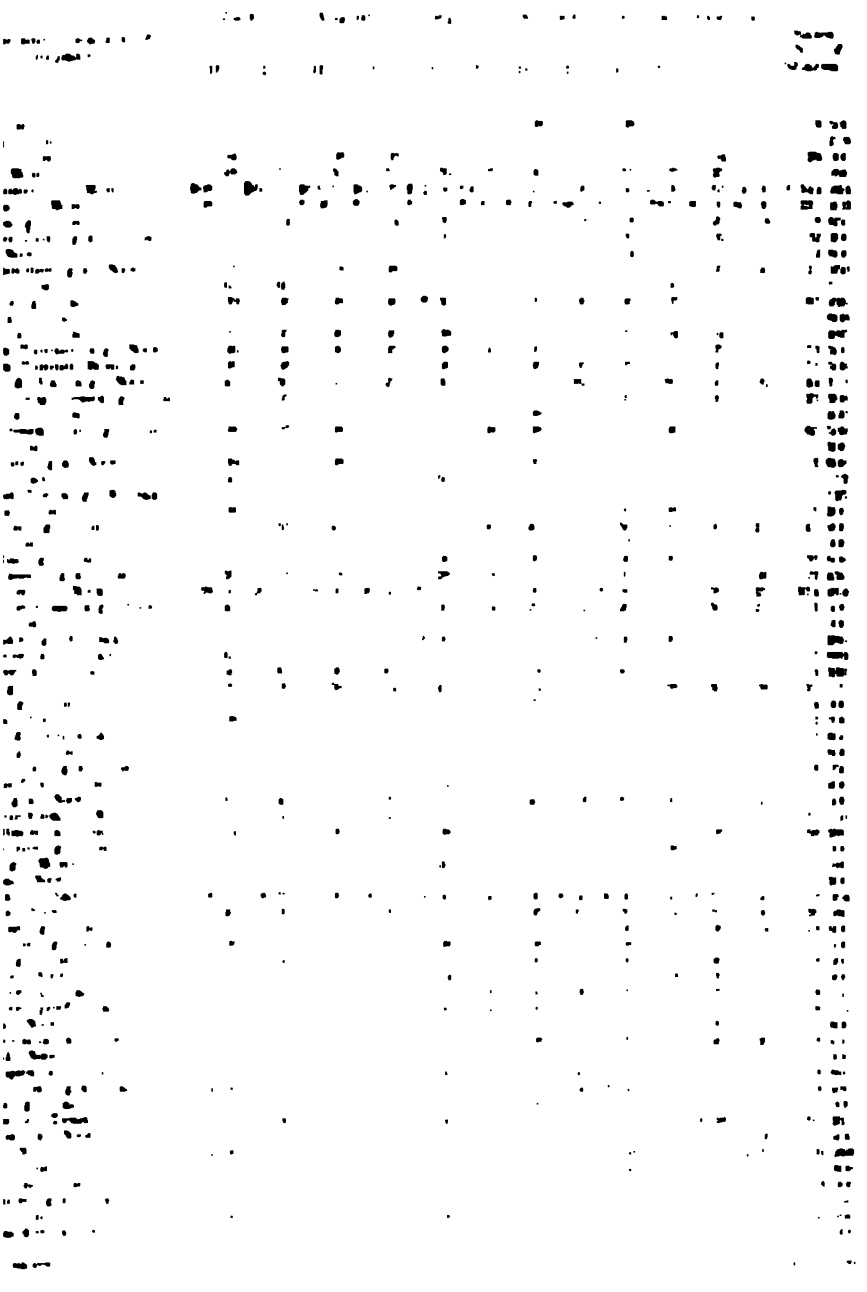
The year was notable for the general liquidation and depression of prices. The low metal market, especially for copper and silver, together with the financial stringency, reacted unfavorably upon mining shares, and the quotations were below the average for the preceding year. The total sales were 8,575,029 shares, as compared with 12,063,196 shares in 1901.

The copper shares attracted widespread attention. Amalgamated pursued a downward course under the influence of the numerous lawsuits in which the company is engaged, the unsettled copper market and professional manipulation. Moreover the cut in the original dividend rate of 8 to 2% per annum had a demoralizing effect. In February the stock brought $79, which, though the *highest* quotation of the year, was 51 points lower than the high mark in June, 1901, and in November the low price of $53 was recorded. Within 10 months



FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1902.

Name and Location of Company	Par Value	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Acacia, Colo.	$1	.....	.....	.....	.....	.....	.....	·11	.....	·11	·05	·11	.....
Adams, g., Colo.	10	·25	.....	.....	.....	·45	.....	.....	.....	.....	.....	.....	.....
Alamo, g., Colo.	1	·15	·14	·14	·13	.....	.....	·05	·05	·05	·05	.....	.....
Alice, g., Mont.	25	.....	.....	·50	·48	·49	·48	·52	.....	.....	.....	·50	·48
Amalgamated, c., Mont.	100	$78·00	$67·63	$79·00	$62·50	70·50	61·00	$67·25	$63·50	$71·88	$65·00	$69·75	$62·25
Anaconda, c., Mont.	25	35·50	29·25	36·50	.....	33·50	28·00	130	110	129	111	117	·05
Anaconda, g., Colo.	5	·26	·24	·30	·25	·22	.....	·23	·20	·19	·18	·19	.....
Argentum-Jun., g. s.l., Colo.	2	·15	·08	·08	·07	·05	·04	·05	·04	·05	·04	.....	.....
Belcher, Nev.	3	·14	·10	·07	.....	·10	·08	.....	.....	.....	.....	.....	.....
Best & Belcher, g.s., Nev.	3	·15	·12	·31	·12	·29	·21	·26	·22	·30	·15	·20	·14
Bressee, s., Colo.	25	·75	.....	·65	.....	.....	.....	.....	.....	.....	.....	·70	.....
Brunswick, g., Cal.	1	·15	·08	·11	·17	·10	·08	·21	·15	·15	·12	·10	·06
Catalpa, s.l., Colo.	10	·14	·12	.....	.....	.....	.....	·10	.....	.....	.....	.....	.....
Chrysolite, s.l., Colo.	50	·05	·04	·10	·05	·05	·04	·04	.....	·06	.....	.....	.....
Comstock Tunnel, s.g., Nev.	2	·07	·06	·06	·05	·06	·05	·06	·05	·07	·06	·06	·06
Comstock Tunnel Bonds.	100	·07	.....	·06	·05	·06	·06	·06	·05	.....	.....	·06	.....
Con. Cal. & Va., s.g., Nev.	2½	1·80	1·15	1·55	1·20	1·40	1·15	1·70	1·25	1·65	1·30	1·50	1·25
Creede & Crip. Creek, g., Colo.	1	.....	.....	·09	·08	·09	·09	.....	.....	.....	.....	.....	.....
Crescent, s.l., Colo.	10	.....	.....	·10	.....	·10	.....	·14	.....	.....	.....	.....	.....
Cripple Creek Con., g., Colo.	1	·11	·07	·11	·09	·09	·08	·08	·08	·08	·07	·08	·07
Croesus, Colo.	1	.....	.....	.....	.....	·10	.....	.....	.....	.....	.....	.....	.....
Crown Point, g.s., Nev.	3	·12	.....	·10	.....	·09	·07	·12	.....	·08	.....	.....	.....
Daly, g., Utah	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Deadwood-Terra, g., S. Dak.	100	.....	.....	·65	.....	·65	.....	·75	·65	.....	.....	.....	.....
Dunkin, s., Colo.	1	·11	·10	.....	.....	·14	·13	.....	.....	.....	.....	.....	.....
Elkton Con., g., Colo.	1	1·33	1·12	1·30	1·20	1·26	1·13	1·00	·74	·72	·63	·68	·61
El Paso, Colo.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gold Dollar, g., Colo.	1	·09	·09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Golden Fleece, g.s., Colo.	1	·40	.....	·45	.....	.....	.....	·37	·30	·30	·27	·23	·21
Greene Con, c., Mex.	10	26·75	25·00	29·25	21·13	25·00	19·50	23·50	19·75	31·38	23·25	20·13	27·00
Hale & Norcross, s.g., Nev.	3	·34	·18	.....	.....	·33	·30	·25	·22	·24	·20	·42	·40
Hart, g., Colo.	1	.....	.....	.....	.....	.....	.....	.....	.....	·05	.....	.....	.....
Homestake, g., S. Dak.	100	.....	.....	99·00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Horn Silver, s.l., Utah.	25	2·00	1·30	1·75	1·40	1·60	.....	1·63	1·40	1·50	1·40	1·50	1·40
Iron Silver, s.l., Colo.	20	·65	·61	.....	.....	·80	·78	·80	.....	.....	.....	·85	·80
Isabella, g., Colo.	1	·33	·28	·30	·25	·28	·23	·28	·23	·37	·24	·32	·28
Jack Pot, g., Colo.	1	·35	·34	·33	·30	·35	·33	·29	·27	·25	.....	·16	·14
Justice, s., Nev.	1	.....	.....	·15	.....	·10	·07	.....	.....	.....	.....	.....	.....
Kingston & Pembroke, l., Ont.	10	·10	.....	·12	·10	·12	·10	.....	.....	.....	.....	·13	.....
Lacrosse, g., Colo.	10	·07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Leadville Con., g.s., Colo.	10	·06	.....	·07	·06	·12	·06	·06	.....	.....	.....	.....	.....
Little Chief, s.l., Colo.	1	·11	·10	·14	·11	·13	·12	·13	·12	·14	·13	·13	.....
Mexican, g.s., Nev.	3	·45	·30	·50	·30	·54	·30	·60	·43	·65	·45	·53	·42
Mine Securities, U. S.	100	.....	.....	.....	.....	.....	.....	8·00	7·00	7·50	6·50	7·25	6·50
Mollie Gibson, s., Colo.	5	·18	·13	·16	·12	·13	·10	·12	·10	·11	·10	·18	·12
Moon-Anchor, g., Colo.	5	.....	.....	·21	.....	·22	·21	.....	.....	·18	.....	·15	.....
Moulton, g., Mont.	25	·27	·25	.....	.....	·20	.....	·25	.....	.....	.....	.....	.....
Occidental, Nev.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ontario, s.l., Utah.	100	9·50	7·88	8·50	8·25	8·50	7·63	9·50	8·50	9·25	7·63	8·90	7·75
Ophir, g.s., Nev.	3	·92	·80	1·25	·82	1·05	·95	1·60	·90	1.80	1·30	1·30	1.05
Pharmacist, g., Colo.	1	.....	.....	·05	.....	·05	.....	·05	.....	.....	.....	·05	.....
Phœnix Con., g., Ariz.	1	·07	·06	·07	·06	·07	.....	·08	·06	·06	.....	·07	.....
Portland, g., Colo.	10	2·75	2·50	2·50	2·45	2·65	2·25	3·25	1·85	3·85	1·75	1·90	1·70
Potosi, g.s., Nev.	3	·18	·16	.....	.....	.....	.....	·23	·15	·38	·22	·35	·19
Quicksilver, q., Cal.	100	4·13	3·75	3·75	3·12	4·25	2·85	3·50	2·35	4·00	3·13	3·75	3·25
Quicksilver, pref., Cal.	100	10·50	9·75	10·00	8·50	11·18	9·75	11·00	.....	10·25	10·00	10·38	9·88
Savage, s., Nev.	2½	·09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sierra Nevada, s., Nev.	3	·25	·19	·17	·14	·15	.....	.....	.....	·30	·25	.....	.....
Silver Hill, Nev.	1	.....	.....	·66	.....	.....	.....	.....	.....	.....	.....	.....	.....
Small Hopes, s.l., Colo.	20	·43	·40	·40	·30	·55	·45	·50	·45	·45	·40	·35	·30
Standard Con., g.s., Cal.	10	3·85	3·40	3·55	2·50	3·65	3·45	3·60	3·25	3·50	.....	3·45	3·25
Syndicate, g., Cal.	10	·05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tennessee, Cop., Tenn.	25	15·00	14·00	15·50	12·00	15·00	10·63	13·60	10·13	13·50	10·00	17·75	13·25
Union Con., s., Nev.	2½	.....	.....	·21	.....	.....	.....	.....	.....	.....	.....	.....	.....
Union Copper, N. C.	10	4·13	2·88	4·00	2·75	4·00	3·50	4·00	3·25	5·63	2·75	5·00	3·63
Union Gold, Colo.	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Virginia Con., Colo.	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
White Knob, g.s., Ida.	100	20·00	15·00	24·00	16·50	24·00	20·13	27·25	20·50	25·75	20·25	23·38	15·75
Work, g., Colo.	1	·11	·09	·18	·06	·09	·07	·08	·08	·08	·07	·07	·07
Yellow Jacket, s., Nev.	3	.....	.....	.....	.....	·20	.....	.....	.....	.....	.....	.....	.....
Total sales.	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

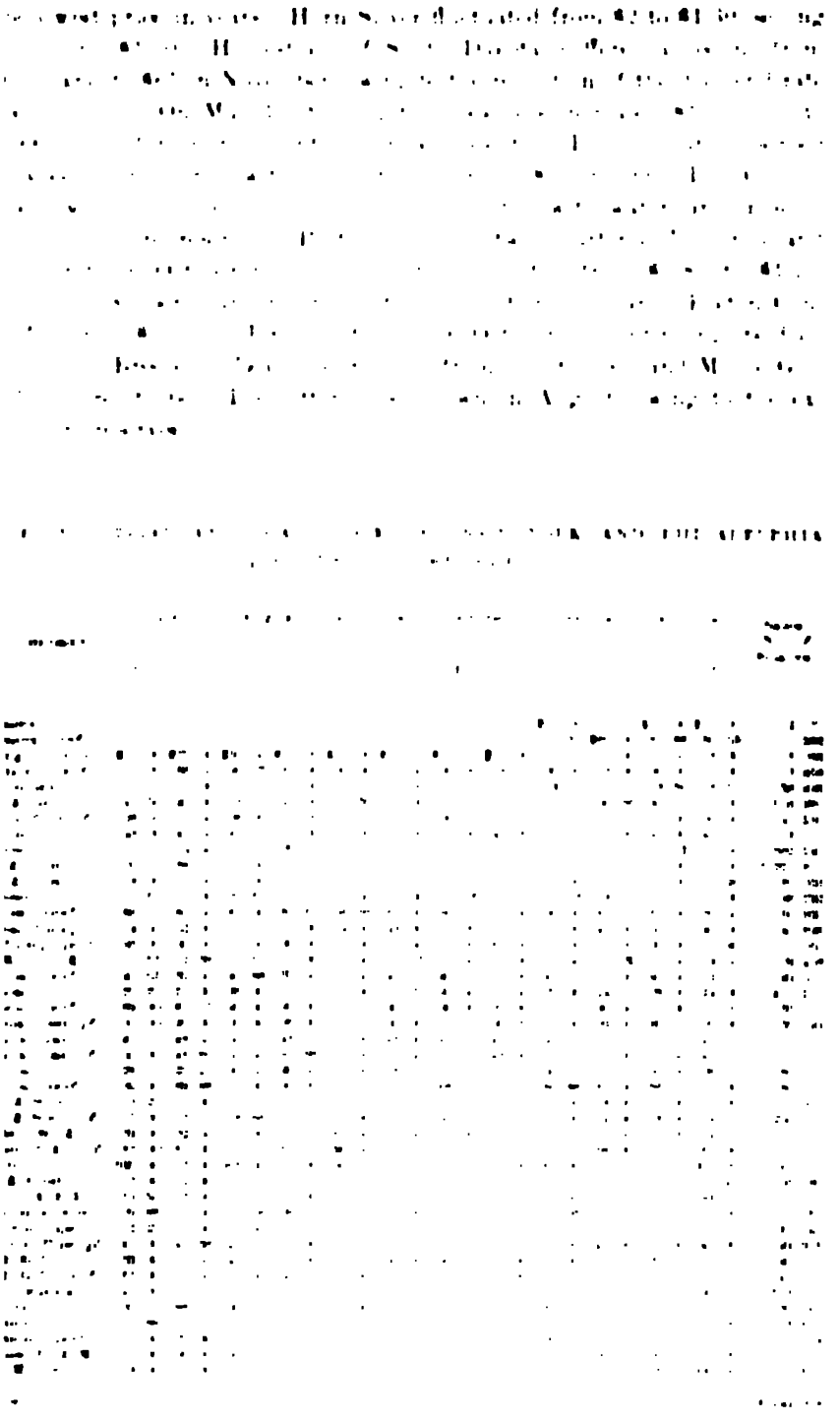


$7,200,000, the additional $1,200,000 being issued to pay its indebtedness. After the increase in capital the new shares sold at $24 @ $22·87. Tennessee Copper, which is closely held, was one of the few stocks that advanced near the close of the year. It rose from $10 12 in April, to $13 37 in October, and in December large sales were made around $18. These prices, however, are lower than in 1901. British Columbia was erratic, due to inside manipulation. In January the price opened at $10, dropping to $8·50 in February, and recovering to $10·50 in March, the highest price for the year. The stock closed at $5 50.

The gold and silver mining shares were generally unsteady, owing to the fluctuations in other stocks, and they responded more or less to bearish influences. A new concern—The Bamberger-De Lamar Gold Mines Co.—made its appearance in August. The company, which is capitalized at $5,000,000, is a consolidation of the properties owned by Capt. De Lamar in Lincoln County, Nev. The subscription price was $10 for 150,000 shares, but sales were made at $9·50 @ $9·50. Ontario Silver, of Utah, paying dividends of 30c. per share, fell to

PRICES OF INDUSTRIAL AND COAL STOCKS AT NEW YORK AND PHILADELPHIA DURING 1902.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Allis-Chalmers	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Allis-Chalmers, pf	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Amer. Agri. Chem	100	$39·00	$20·00	$36·00	$21·00	$24·50	$21·00	$30·50	$22·00	$29·50	$25·00	$29·00	$25·00
Am. Ag. Chem., pref	100	89·00	82·50	89·00	81·00	90·00	82·50	87·50	82·00	91·00	82·00	91·25	85·00
American Cement	10	6·38	5·50	6·00	5·63	5·75	5·50	7·38	5·75	7·25	7·00	7·75	7·13
Amer. Sm. & Ref	100	49·13	44·75	48·25	45·75	47·50	46·00	48·25	43·50	49·63	43·50	49·25	47·00
Am. Sm. & Ref., pref	100	98·00	96·00	99·00	97·13	99·50	96·13	98·00	95·00	98·00	95·00	100·13	85·00
Cambria Iron	50	48·25	47·75	48·00	37·88	48·80	46·88	48·00	46·88	48·00	47·50	47·75	47·50
Cambria Steel	50	28·00	23·75	24·13	23·75	24·00	23·13	28·00	23·75	24·88	23·00	24·63	23·13
Colo. Fuel & Iron	100	88·25	84·00	88·00	84·25	100·00	86·50	110·50	95·50	108·38	95·75	100·50	85·00
Colo. H. C. & Iron	100	17·13	14·38	18·50	15·50	22·25	16·50	23·75	19·88	20·25	17·75	17·50	16·00
Curcible Steel	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22·38	21·50
Crucible Steel pref	100	80⅞	.....	.....	.....	.....	.....	.....	.....	.....	.....	87·75	85·25
International Pump	100	52·00	46·75	53·25	50·50	57·25	50·00	55·88	52·50	56·00	53·00	55·00	51·00
International Pump, pref	100	90·00	85·00	91·00	85·00	94·00	89·50	94·00	88·00	94·00	87·00	94·00	85·00
Monongahela R. Con. C. & C.	100	13·75	12·88	14·50	13·25	13·88	13·00	13·50	13·00	13·00	12·88	12·88	12·38
Mong. R. Coal, pref	100	44·00	43·25	44·00	42·50	44·00	42·00	43·63	43·00	42·88	41·00	42·50	41·50
National Lead	100	19·63	15·38	19·00	17·13	20·88	16·88	20·88	17·88	23·50	18·13	23·00	21·00
National Lead, pref	100	86·00	78·00	87·00	80·00	86·25	81·00	89·88	85·00	91·00	87·00	89·00	88·25
Pennsylvania Steel, pref	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Philadelphia Natural Gas	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phila. Natural Gas, pref	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pittsburg Coal	100	28·00	25·00	26·00	25·13	25·25	25·00	25·63	24·50	25·00	23·25	27·25	24·00
Pittsburg Coal, pref	100	92·75	90·00	91·00	90·00	92·50	90·00	92·00	89·00	90·00	85·63	90·50	88·88
Republic I. & Steel	100	17·50	15·63	17·25	16·13	18·50	16·13	20·00	17·00	19·50	16·63	18·25	17·00
Republic I. & Steel, pref	100	70·00	68·00	70·50	69·00	75·25	71·38	76·00	72·50	75·25	72·25	75·63	72·75
Sloss-Sheffield St. & Iron	100	31·00	29·00	33·00	29·50	35·00	32·00	34·00	32·00	33·00	29·00	34·00	30·00
Sloss-Sheffield St. & Iron, pref	100	83·00	80·00	83·50	81·00	84·50	82·00	83·50	79·00	82·50	78·00	83·00	80·00
Standard Oil	100	700·00	630·00	665·00	635·00	650·00	630·00	650·00	612·00	645·00	625·00	657·00	620·00
Susq. Iron & Steel	10	2·00	1·63	2·00	1·43	2·25	2·00	2·25	2·00	2·25	2·06	3·00	2·25
Tenn. Coal, I. & R.R.	100	67·25	61·50	71·25	63·00	72·63	67·50	74·63	67·25	71·25	61·50	65·00	61·50
United Gas Improvement	50	126·00	115·00	122·00	116·00	123·00	120·00	123·00	120·00	122·00	*101·50	108·50	103·00
U. S. Cast Iron Pipe	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
U. S. C. I. P., pref	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
U. S. Red & Ref	100	.....	.....	42·00	38·50	44·50	40·00	44·00	39·50	43·50	39·00	41·00	30·00
U. S. Red & Ref., pref	100	.....	.....	66·50	63·75	67·38	64·50	65·75	63·00	65·25	63·00	66·00	51·50
U. S. Steel Corporation	100	46·75	41·63	44·75	43·00	43·50	41·75	43·88	40·88	42·13	38·25	40·25	36·75
U. S. Steel, pref	100	97·75	92·38	95·50	93·00	95·75	93·38	94·75	92·50	92·38	88·75	90·38	87·50
Virginia-Car. Chem	100	63·00	59·00	63·00	60·00	69·88	62·25	76·38	68·63	75·25	70·00	70·88	69·50
Virginia-Car. Chem., pref	100	123·50	120·00	123·00	120·00	133·00	121·00	132·63	130·00	134·00	131·25	132·50	131·00
Westinghouse E. & M	50	177·50	173·50	179·50	173·50	.....	.....	.....	.....	.....	.....	212·00	209·00
Westinghouse E. & M., pref	50	187·00	180·00	180·00	175·00	.....	.....	.....	.....	.....	.....	.....	.....
Total sales	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....



REVIEW OF ENGLISH MINING COMPANIES AT LONDON (*a*) DURING 1902.

Name of Company.	Location.	Authorized Capital.	Par Value.	Total Divid'nds Paid During 1902.	Fluctuations of Quotations, 1902. Highest.	Lowest.
		£	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Alaska-Treadwell, *g*	Alaska	1,000,000	5 0 0	6 0	5 2 6	3 17 6
Camp Bird, *g*	Colorado	1,100,000	1 0 0	1 3	1 8 9	15 0
El Oro, *g*	Mexico	1,150,000	1 0 0	4 6	1 13 9	1 2 6
Le Roi, *g*	British Col.	1,000,000	5 0 0	.....	4 7 6	18 9
Le Roi No. 2, *g. s. c.*	British Col.	600,000	5 0 0	5 0	5 17 6	11 3
Montana, *g. s.*	Montana	660,000	1 0 0	.....	5 3	2 3
Mountain Copper, 6% Deb., *c*	California	1,000,000	4 0 0	4 0	5 5 0	4 12 6
Stratton's Independence, *g*	Colorado	1,100,000	1 0 0	6 0	15 0	4 0
Copiapo, *c*	Chile	250,000	2 0 0	.....	2 12 6	17 6
Frontino & Bolivia, *g*	Colombia	140,000	1 0 0	.....	1 11 3	11 3
Ouro Preto of Brazil, *g*	Brazil	140,000	1 0 0	6	7 9	3 6
Rossland Kootenay, *g. s. c.*	British Col.	150,000	1 0 0	.....	8 9	5 0
Snowshoe, *g. c.*	British Col.	250,000	1 0 0	.....	1 0 0	17 6
Tomboy, *g*	Colorado	300,000	1 0 0	1 0	2 9 6	1 9 6
St. John del Rey, *g*	Brazil	600,000	1 0 0	1 0	1 0 0	14 6
Ymir, *g*	British Col.	200,000	1 0 0	1 0	2 6 3	2 6
Linares, *l*	Spain	45,000	3 0 0	2 0	5 7 6	2 0 0
Mason & Barry, *c.sul*	Portugal	210,000	1 0 0	13 0	4 5 0	3 2 6
Rio Tinto, *c*	Spain	1,625,000	5 0 0	3 0	47 7 6	38 7 6
Rio Tinto, Pref., *c*	Spain	1,625,000	5 0 0	5 0	6 5 0	6 0 0
Tharsis, *c*	Spain	1,250,000	2 0 0	8 0	7 12 6	3 12 6
Broken Hill Prop., *s*	N. S. Wales	384,000	8 0	2 0	1 17 6	1 1 6
Golden Horseshoe, *g*	W. Australia	1,500,000	5 0 0	18 0	11 15 0	7 0 0
Great Boulder Perseverance (old) *g*	W. Australia	175,000	1 0 0	2 0 0	13 11 3	8 8 9
Great Boulder Prop	W. Australia	175,000	2 0	2 6	1 1 6	17 9
Great Fingall, *g*	W. Australia	125,000	10 0	11 6	9 8 9	5 8 9
Ivanhoe Gold Corp., *g*	W. Australia	1,000,000	5 0 0	13 0	8 5 0	6 15 0
Kalgurlie, *g*	W. Australia	120,000	1 0 0	2 6	4 5 0	2 16 3
Lake View Consols, *g*	W. Australia	350,000	1 0 0	.....	6 15 0	1 13 9
Mt. Lyell M. & R., *l.c*	Tasmania	900,000	3 0 0	7 6	4 10 0	2 0 0
Mt. Morgan, *g*	Queensland	1,000,000	1 0 0	3 3	4 12 6	3 10 0
Oroya Brownhill, *g*	W. Australia	450,000	1 0 0	2 0	2 10 0	2 1 3
Waihi, *g*	New Zealand	500,000	1 0 0	10 0	6 2 6	4 18 9
Champion Reef, *g*	Colar Fields	236,500	10 0	10 0	7 0 0	5 7 6
Mysore, *g*	Colar Fields	290,000	10 0	13 0	7 12 6	5 16 3
Nundydroog, *g*	Colar Fields	242,000	10 0	3 9	2 6 3	1 12 6
Ooregum, *g*	Colar Fields	171,500	10 0	3 9	2 17 6	1 10 0
Ooregum, Pref., *g*	Colar Fields	120,000	10 0	4 9	3 0 0	1 17 6
British S. Af. Chartered	South Africa	5,000,000	1 0 0	.....	4 10 0	2 16 3
Cape Copper, *c*	South Africa	300,000	2 0 0	8 0	5 0 0	2 0 0
Cape Copper, Pref., *c*	South Africa	150,000	2 0 0	10 3	4 15 0	2 18 9
City & Suburban, *g*	Transvaal	1,360,000	4 0 0	.....	7 15 0	5 17 6
Crown Reef, *g*	Transvaal	120,000	1 0 0	1 5 0	18 10 0	16 5 0
De Beers, Def., *d*	Cape Colony	2,500,000	2 10 0	12 6	26 2 6	21 0 0
Ferreira, *g*	Transvaal	90,000	1 0 0	.....	26 0 0	22 0 0
Geldenhuis Est., *g*	Transvaal	200,000	1 0 0	5 0	7 15 0	6 2 6
Henry Nourse, *g*	Transvaal	125,000	1 0 0	.....	10 5 0	8 7 6
Jagersfontein, *d*	OrangeRiv.Col.	1,000,000	5 0 0	.....	30 0 0	24 0 0
Johannesburg Con. Invest.	South Africa	2,750,000	1 0 0	.....	4 3 9	2 12 6
Jubilee, *g*	Transvaal	50,000	1 0 0	.....	7 10 0	4 15 0
Langlaagte Est., *g*	Transvaal	470,000	1 0 0	.....	5 1 3	3 7 6
May Con., *g*	Transvaal	290,000	1 0 0	6 0	5 8 9	4 5 0
Meyer & Charlton, *g*	Transvaal	100,000	1 0 0	6 0	6 10 0	5 7 6
Namaqua, *c*	Cape Colony	200,000	2 0 0	2 0	4 7 6	2 2 6
Primrose (new), *g*	Transvaal	325,000	1 0 0	.....	5 8 9	3 10 0
Rand Mines, *g*	Transvaal	490,000	5 0	4 0	13 3 9	10 5 0
Robinson, *g*	Transvaal	2,750,000	5 0 0	12 6	12 0 0	10 5 0
Sheba, *g*	Transvaal	1,250,000	1 0 0	.....	13 9	1 2 6
Simmer & Jack Prop., *g*	Transvaal	3,000,000	1 0 0	.....	2 12 6	1 13 9
Wolhuter, *g*	Transvaal	860,000	4 0 0	.....	6 10 0	4 2 6

(*a*) Specially prepared for THE MINERAL INDUSTRY by Fred. C. Mathieson & Sons, London. *c.*, copper; *d.*, diamonds; *g.*, gold; *l.*, lead; *s.*, silver.

Prices of the Comstock stocks were forced down by the continued assessment policy. Consolidated California and Virginia paid a dividend in 1901, but it was compelled to levy another assessment in 1902, and the shares fell from $1·80 in January, to 80c. in November, recovering to $1·35 in December. Ophir, Best & Belcher, and Mexican also levied assessments.

The United States Reduction & Refining Co., the mill combination of Cripple Creek, was listed on the New York Stock Exchange. The 6% preferred stock,

Mysore Government was renewed for a further period of 30 years, dating from 1919.

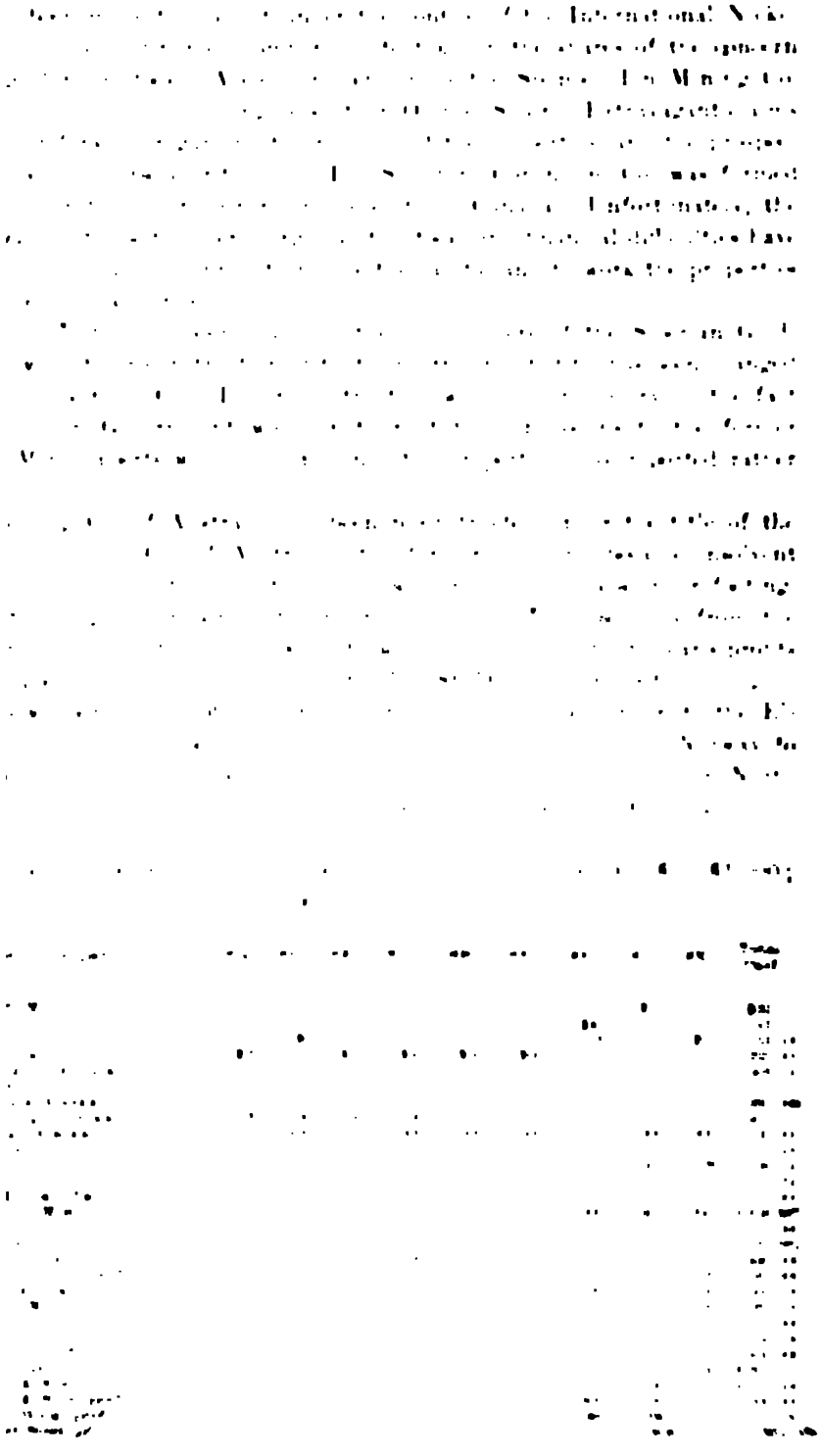
The Western Australian market was generally free from any disturbing elements such as have characterized previous years. Lake View Consols and other mines have passed out of the hands of the Whittaker-Wright group, and the management has been given over to the firm of Bewick, Moreing & Co. In a report by this company, additional capital for working the Lake View Consols mine was recommended, and it is now expected that the mine will again become a dividend payer, although on a considerably less scale than formerly. The Great Fingall mine in the Murchison district was prominent during the year both as producer and in the speculative markets.

The Le Roi mine has furnished many disappointments, and many contradictory reports have been issued at various times during the year as to estimated and realized profits. Shareholders agree that the dividing line between profit and loss depends on several things; any one of which may effect the position seriously. Very little interest is now manifested in the shares, and the same may be said of Le Roi No. 2. The prospect of the two mines is not very promising, although under the new management better results may be obtained in the future. The other British Columbia mines operated from London have proved a disappointment. The Ymir has been compelled to raise additional capital for a new plant and further development. The Velvet has also been reconstructed, while the Hall mine is unable to make a profit.

Of the mines in the United States, Stratton's Independence commanded the largest share of public attention. Shareholders have been dissatisfied with the management of the company, and the contradictory reports of the various experts have formed the subject of acrimonious discussions. The somewhat uncertain tone of Mr. Hammond's reports have made it impossible for shareholders to judge the actual position. The unsatisfactory administration of this mine has deterred capitalists from becoming interested in the Camp Bird mines, although no very great efforts have been made by the underwriters of this company to dispose of their shares.

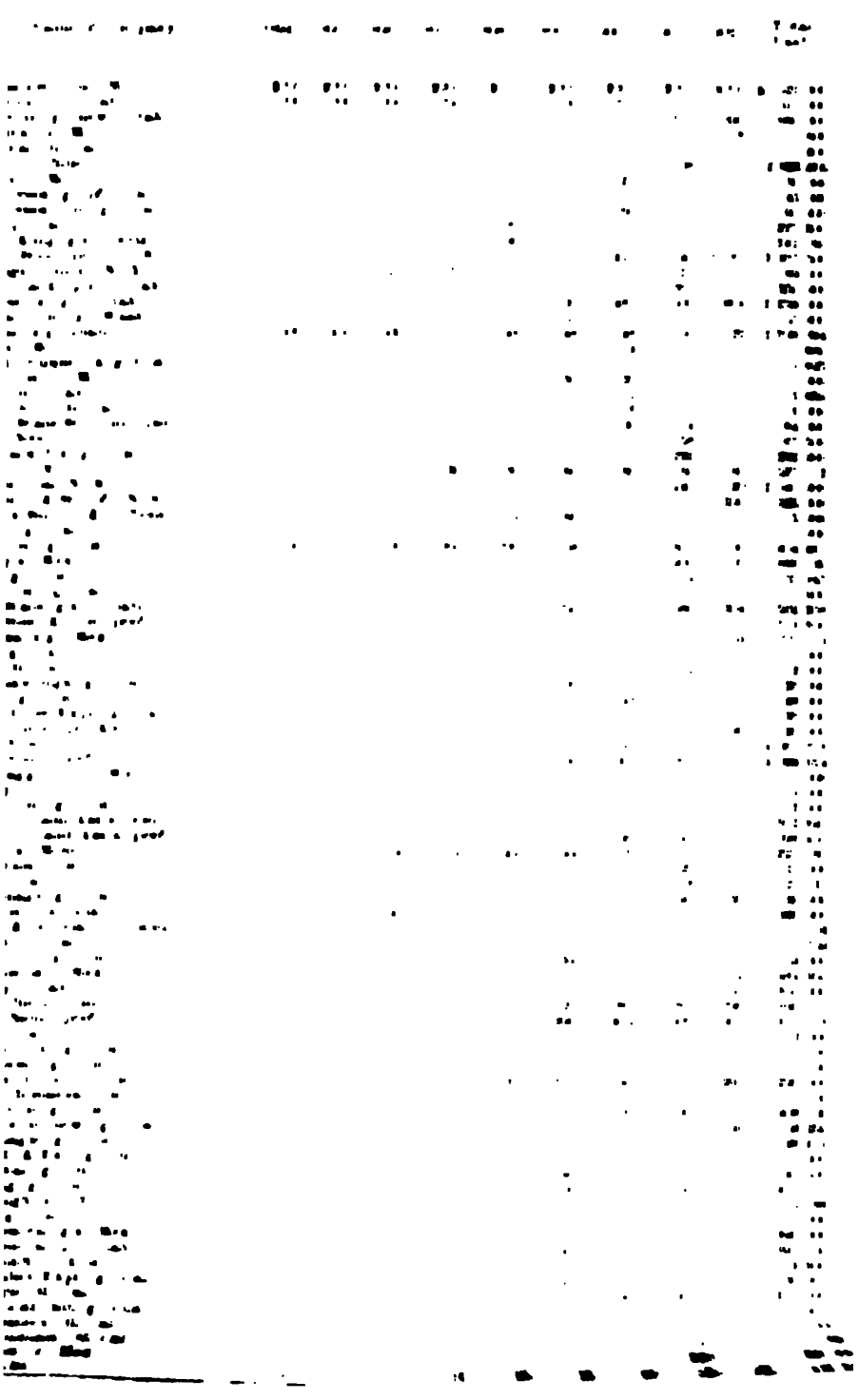
The Etruscan Copper Estates, a company formed two years ago to acquire gold mines in Italy, received much notice. The properties owned by the company were examined by competent engineers, who found that the veins were poor, although of considerable extent, and that the ore could not be treated satisfactorily owing to the amount of zinc present. In spite of the verdict of these experts, however, the directors and shareholders have decided to work the mines. Another new company is the Dunderland Iron Ore Co., which was publicly floated during the year with a large capital to acquire and work a low-grade iron ore deposit in Norway. It is planned to use the Edison magnetic process for concentrating the ore. The company received general support, as the mine will afford a new supply of iron ore for English furnaces. There is still some doubt, however, as to the cost of concentrating and briquetting and as to the quality of the material from a metallurgical standpoint.

The Nickel Corporation working properties in New Caledonia was taken over last year by people connected with the London metal trade, and arrange-



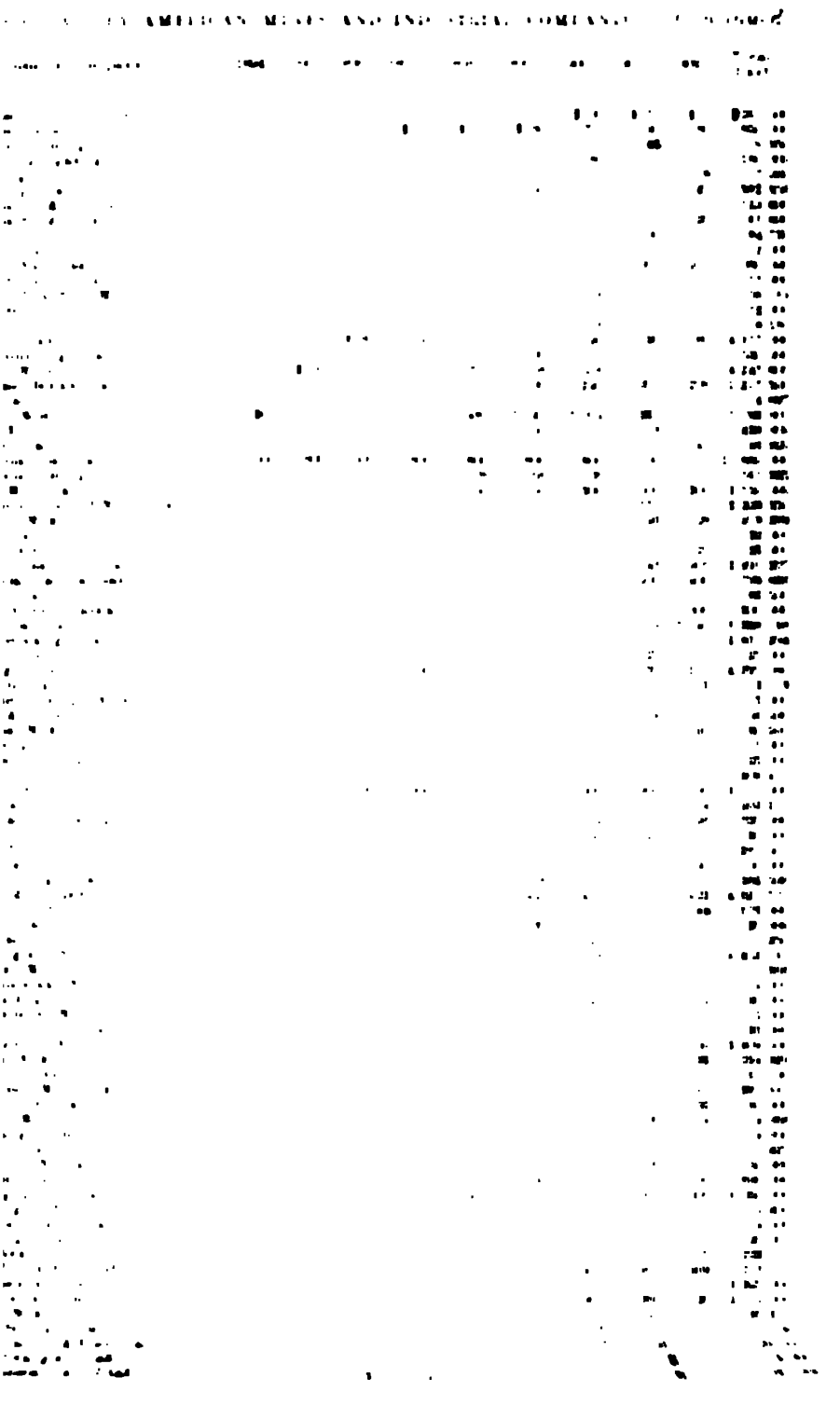
DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—Continued.

Name of Company.	1904	1905	1906	1907	1908	1909	1910	1911	1912	Total Paid
Am. Zinc-Lead Sm., Mo.						$120	$80			$200
Amparo y Consorcio, Mex.								$77	$92	169
Anaconda, c., Mont.					$6,000	8,000	4,000	2,000	2,000	22,000
Anchoria-Leland, g., Colo.			$91	$72	72	36				270
Andersen, g., Colo.							15			15
Anglo-Mexican, g., Mexico		$361	271	91	140	140				1,023
Annie Laurie, g.s., Utah									60	60
Apollo Con., g., Alaska				100		60	70			130
April Fool, g., Nev.						16				16
Argentum-Juniata, s., Colo.		150				42				192
Argonaut, g., Cal.					140	280	70			490
Arizona, c.s., Ariz.					675	722	570	405	1,115	3,485
Arizona Western Oil, Cal.							6			6
Arrow, g., Colo.								30		30
Associated, g., Colo.					50	12				62
Atlantic, c., Mich.				40	40		60	40		180
Aztec Oil, Cal.								12	16	28
Bald Butte, g., Mont.	$172	127	28	63	28	150	28	140	140	1,276
Bankers, g., Colo.								148		148
Barcadera de Medina, Mex.									20	20
Bethlehem Steel, Pa.						300	600	435		1,335
Big Four, g., Colo.							15			15
Blue Bird Extension, Utah								1		834
Bonanza Dev., g., N. Mex.						1,050				1,050
Boston, q., Cal.						20				20
Boston & Colo. Sm., Colo.						56	34	45	45	492
Boston-Aurora, z., Mo., pref.						29	37			66
Boston-California, g., Cal.						72				72
Boston-Duenweg, z., Mo.						32	24			56
Boston Get There, z., Mo.						11	9			20
Boston Gold-Cop. Sm., Colo.							50	100		150
Boston-Little Circle, z., Mo.						75	13	25		112
Boston & Montana, c.s., Mont.	275	1,050	1,500	1,800	1,950	5,375	6,450	5,250	900	27,125
Boston-Phila., z.l., Kas.							2			2,000
Boston-Providence, z., Mo.						11	6			17,362
Boston S. Dak., g., S. Dak.							10			10,000
Boston-Springfield, z., Mo.							15			15,000
Boston-Sunflower, z. Mo.						5				4,500
Boun, s.l., B. C.								13		12,500
Breeze, l.s., Colo					10	40	30	70	20	190,600
Buckeye, g., Colo.							160			160,000
Buckhorn Oil, Cal.							4	4		3,800
Buffalo Hump, g., Idaho							275	25		300,000
Bull Hill, Con., g., Colo.							15	38		37,500
Bull'n-Beck & Cham., g.s., Utah	425	325	200	170	90	120	60			2,498,400
Bunker Hill & Sull., s.l., Idaho				102	228	201	252	252	156	1,442,000
Burlington Oil, Cal.							3			3,600
Butte & Boston, c.s.l., Mont.							1,000	600		1,600,000
Butterfly-Terrible, g., Colo.								31		31,250
California, g., Cal.								43		43,200
California Oil & Gas, Cal.								540		540,000
Calumet & Hecla, c., Mich.	1,500	2,000	2,500	5,000	5,000	10,000	7,000	4,500	2,500	79,850,000
Cambria Iron, Pa.						339	339	339		1,015,900
Cambria Steel, Pa.						660	940	2,150	1,350	5,100,000
Camp Bird, g., Colo.									221	221,400
Caribou-McKinney, g., B. C.			49	76	48	67	72	88		19
Carisa, g.s.c., Utah								30		30,000
Cent'l Eureka, s.g.l., Utah		195	510	390	98	15	120	268	200	50
Center Creek, l.z., Mo.							10	30	20	10
Center Star, g., B. C.								35	175	
Central, l., Mo.					28	54	60	65	60	60
Central C. & Coke, com., Mo.										198
Central C. & Coke, pf., Mo.										84
Central Eureka, Cal.								16		8
Central Oil, Cal.							73	25		24
Central Oil, W. Va.							23	63		75
Central Point Con. Oil, Cal.							4	38		
Champion, g., Cal.		41	27		51	26	35			
Charleston, phos., S. C.						30	20			
C. K. & N., g.s., Colo										14
Cherry Hill, g., Cal.								23		30
Chicago Oil, Cal.										10
Chippewa Con., g.s.l., Colo.										3
Cinco Sonores, Mex.								9		57
Cloverdale, z., Mo.						40	40			
Colonial, l., Mo.						10				
Colo. City Mg. & Leas., Colo.										60
Colorado Fuel & Iron, com.								682	805	1,642
Colo. Fuel & Iron, Colo., pref.	160		160	8			800	160	160	1,480
Columbia, l., Mo.							12			12
Commodore, g., Colo.				20	20	48				432
Commonwealth, z., Mo., pref.						20	30			50
Consolidated, g., Colo.						10	110	182	70	372
Consolidated, z.l., Mo., pref.										4



DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
Hanford Oil, Cal.								$6	$7	$13,000
Hecla, l.s., Idaho							$100			100,000
Hecla Con., s.l., Mont	$120	$90	$45	$30		$15	50	30		2,250,000
Helena, g., Oregon							45	72		116,500
Helena & Liv., S. & R., Mont							90			90,000
Heywood Oil, Tex							32			32,000
Hidden Treasure, g., Cal							29			457,452
Higgins Oil, Tex									97	96,850
Holy Terror, g., So. Dak				36	$81	50	5			172,000
Home, g., Colo							100	137		237,200
Home Oil, Cal							300	61	90	330,000
Homestake, g., So. Dak	256	344	375	375	630	963	1,200	1,260	1,058	11,712,150
Homestake Oil, Cal							23	12	1	33,039
Horn Silver, g.s.l.z.c., Utah	150	50	50		80	20	20	72		5,342,000
Horseshoe, g., So. Dak									420	420,000
Houston Oil, pf., Tex								224	448	672,375
Idaho, g., B. C						28				202,000
Idaho, g., Idaho							8			8,188
Imperial Oil, Cal								20	24	260,000
Independence Con., g., Colo							100	181		281,375
Ingham Con., g., Colo								34		33,981
Int'l Ach. Graph., pf., N. Y									35	70,000
Iowa, g.s.l., Colo			50	25	10		39	67	67	270,501
Iron Silver, s.l., Colo							50			2,550,000
Isabella, g., Colo		23	180	68		270	158	23		742,500
Jack Pot, g., Colo						175				175,000
Jackson, g., Cal		2					6			6,000
Jamison, g., Cal						12		12		62,400
Jeff. & Clearf. Coal, Pa., com							30	30	75	105,000
Jeff. & Clearf. Coal, Pa., pref					75	75	75	75	75	525,000
Katinka, g., Colo								10		10,000
Kend. & Gelder Sm., Colo								20		20,000
Kennedy, g., Cal								10		1,801,000
Kentucky I. & Coal, Ky						11				164,041
Kern Oil, Cal							375	25	20	370,000
Kern River Oil, Cal							10			10,000
La Fortuna, g., Ariz				188	238	238	238	150	100	1,166,000
Lake City, g., Colo							4			3,875
Lake Superior, l., Mich		84			252	84				2,132,000
Last Chance, g., B. C					20	25				45,000
Last Dollar, g., Colo						30	90	60		180,000
Lawrence, g., Colo							10			10,000
Lehigh Coal & Nav., Pa	574	574	574	574	574	574	789	861	717	20,095,120
Le Roi, g., B. C						240				1,305,000
Le Roi No. 2, g., B. C								144	144	288,000
Liberty Bell, g.s., Colo									13	13,035
Lightner, g., Cal							10	18	5	33,230
Lillie, g., Colo					50	136	45			349,188
Los Angeles Oil & Trans., Cal								3		2,500
Madison, g., Colo							35			35,000
Magnolia, g., Colo							187		11	198,000
Mammoth, g.s.c., Utah			100		200	260	200	160		1,840,000
Marion Con., g., Colo						5				300,000
Maryland Coal, Md., pref	66	85	94	75	85	94	94	104	141	885,544
Mary McKinney, g., Colo						30	150	150	120	450,000
May Day, Utah								18	12	30,000
Mesquital, Mex								36		36,458
Midget, g., Colo							25	15	30	195,000
Mo. Zinc Fields, Mo., pref						21	11			31,885
Modoc, g., Colo				10	90	45	60	35	25	250,000
Monarch, g., Colo							120			120,000
Monongahela R.C. & C., Pa., pref							700	694		1,388,660
Montana Coal & Coke, Mont							120			120,000
Montana, g.s., Mont		205			36	99				453,700
Montana Ore Purchas., Mont		160	320	160	160	560	240	722	324	2,646,000
Monument, g., Colo					13	6		3		21,124
Morning Star, g., Cal					82	63	7			854,400
Morse, g., Colo						15				215,620
Mountain, c., Cal				31	62	1,080	1,200	720	540	3,633,750
Mount Diablo, s., Nev							5			260,271
Mount Rosa, g., Colo			5	10	20	40				75,000
Mount Shasta, g., Cal						6				6,000
Napa Con., q., Cal	50	80	70	80	80	110	40	40	40	1,180,000
National Lead, com	447	149			149	149	149		298	1,341,486
National Lead, pref	1,490	1,192	1,043	1,043	1,043	1,043	1,043	1,043	1,043	12,936,593
National Salt, com							245	420		615,000
National Salt, pref						175	350	350		875,000
National Steel, pref						1,418	1,891	945		4,252,500
National Tube, com							1,196	1,196		2,391,624
National Tube, pref						700	2,800	2,800		6,299,410
Natividad, s.g., Mex								24	48	164,926
New Central Coal, Md	50				20	40	40			510,000
New Idria, q., Cal				10	70	110	80	70	80	460,000
N. J. & Mo., z., Mo							11			33,000
N. J. Zinc				900	900	900	1,800	900	720	5,220,000

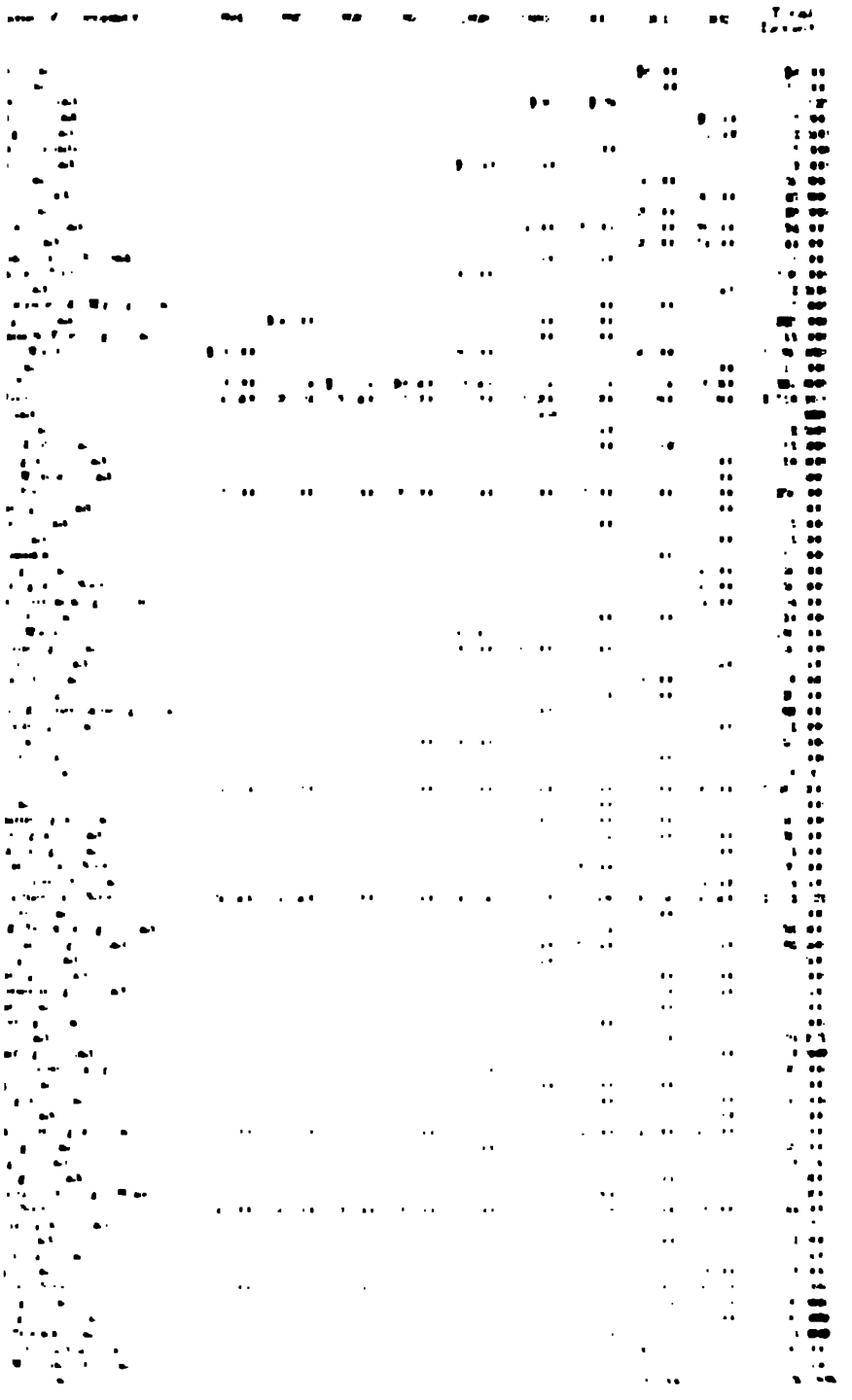


DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Concluded.*

Name of Company.	1894	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
South Winne, g.s., Colo.								$15		$15,000
Spearfish, pf., So. Dak.									$18	17,640
Specie Payment, g., Colo.								27	14	40,500
Specimen, g., Colo.							$153			153,367
Squaw Mountain, g., Colo.						$10				10,000
Sta. Gertrudis, Mex.								81	88	2,647,344
Sta. Maria de Guad, Mex.								133	85	377,978
Sta. Maria de la Paz, Mex.									104	1,889,622
Standard, s.l., Idaho							320	300	150	2,220,000
Standard Con., g., Cal.	$40	$20		$40	$27	60	71	71	71	4,306,814
Standard Oil of N. J.						36,325	47,800	46,660	43,650	164,035,000
St. Eugene Con., s., B. C.						2		210		210,000
St. John del Rey, g., Braz.								102	142	14,005,995
Stratton's Independ., g., Colo.						976	1,789	788	240	3,770,800
Strong, g., Colo.				250	300	300	300	300	375	2,275,000
Sunday Lake Iron, Mich.								40		40,000
Sunset, s.l., B. C.									6	6,000
Susquehanna I. & St., Pa.						180	113	68	90	672,500
Swansea, s.l., Utah			$20	50	65	65	75	29		330,500
Syndicate, g., Cal.									2	82,000
Tamarack, c., Mich.	400	400	500	360	440	600	1,020	1,200		8,490,000
Tennonj, g., Colo.		10					250			250,000
Temple Iron, Pa.									7	7,200
Tenn. C., I. & R. R., com.							451			1,102,144
Tenn. C., I. & R. R., pref.							139	20	20	282,880
Texas & Pacific Coal, Tex.						140	120	120	120	2,040,000
Thirty-three Oil, Cal.									120	120,000
Thomas Iron, Pa.									200	200,000
Tomboy, g., Colo.		300	300		50	152	144	216	72	1,344,000
Touraine, g., Colo.							88	9		96,119
Town Topics, g.c., Colo.								15	20	35,000
Uncle Sam Con., g.s., Utah								45		45,000
Union, g., Colo.		27	13	23			313	25	25	445,254
Union, z.l., Kas.							9	7		16,000
Union Mill, Mex.								31	26	378,250
Union Oil, Cal.								118	179	297,250
United, c., pf., Mont.									150	150,000
United, g., Colo.									280	279,842
United, z.l., Mo.						3	28	30	47	107,259
United Petroleum, Cal.									34	33,750
United States Crude Oil, Cal.							3	24		27,220
U. S. Crude Oil, Cal.							3	24		27,220
U. S. Marble, Wash.								20		20,000
U. S. Oil, W. Va.						300	275			575,000
U. S. Red. & Ref., com.									177	177,326
U. S. Red. & Ref., pf.									236	236,073
U. S. Steel Corp., com.								15,208	20,333	35,540,541
U. S. Steel Corp., pf.								26,753	35,720	62,473,072
United Verde, c., Ariz.						3,000	4,499			
Utah, g., Utah		17	22	4		2	2	14	12	207,000
Utah Con., c., Utah								7.2		782,000
Vindicator, g., Colo.					138	178	189	170	253	917,000
Va.-Car. Chem., com.			10	40	40	270	360	480	1,329	2,979,000
Va.-Car. Chem., pref.						800	800	920	960	6,060,000
Ventura Con. Oil, Cal.									5	5,000
Vic. C. & Coke, com., W. Va.								15		15,000
Vic. C. & Coke, pf., W. Va.								9	6	15,000
War Eagle, g., B. C.					177	315	53			540,250
Warner Oil, Cal.								10		10,000
Warwick Iron & Steel, Pa.						64	132	84		279,224
Wasp No. 2, g., So. Dak.								4	9	218,410
Weatherly-Bonanza, g., Wash.						2				2,000
West Lake Oil, Cal.							50			50,000
West Shore Oil, Cal.								20	25	45,000
Westmoreland Coal						750	750	750	750	7,500,000
What Cheer, z., Mo.						2	9			11,250
White Rock, g., Nev.									2	2,000
Whittier Con. Oil, Cal.							6			5,600
Wolverine, c., Mich.					60	210	240	240	240	990,000
Wythe, l.s., Va.							76			76,000
Yankee Con., g.s.l., Utah									75	75,000
Yellow Aster, g., Cal.				40	131	145	150		30	496,000
Ymir, g., B. C.						30		192	48	288,000
Yreka, g., Cal.							50	8		58,000
Yukon Oil, Cal.						3	18			21,000
Zoe, g., Colo.							8			7,500

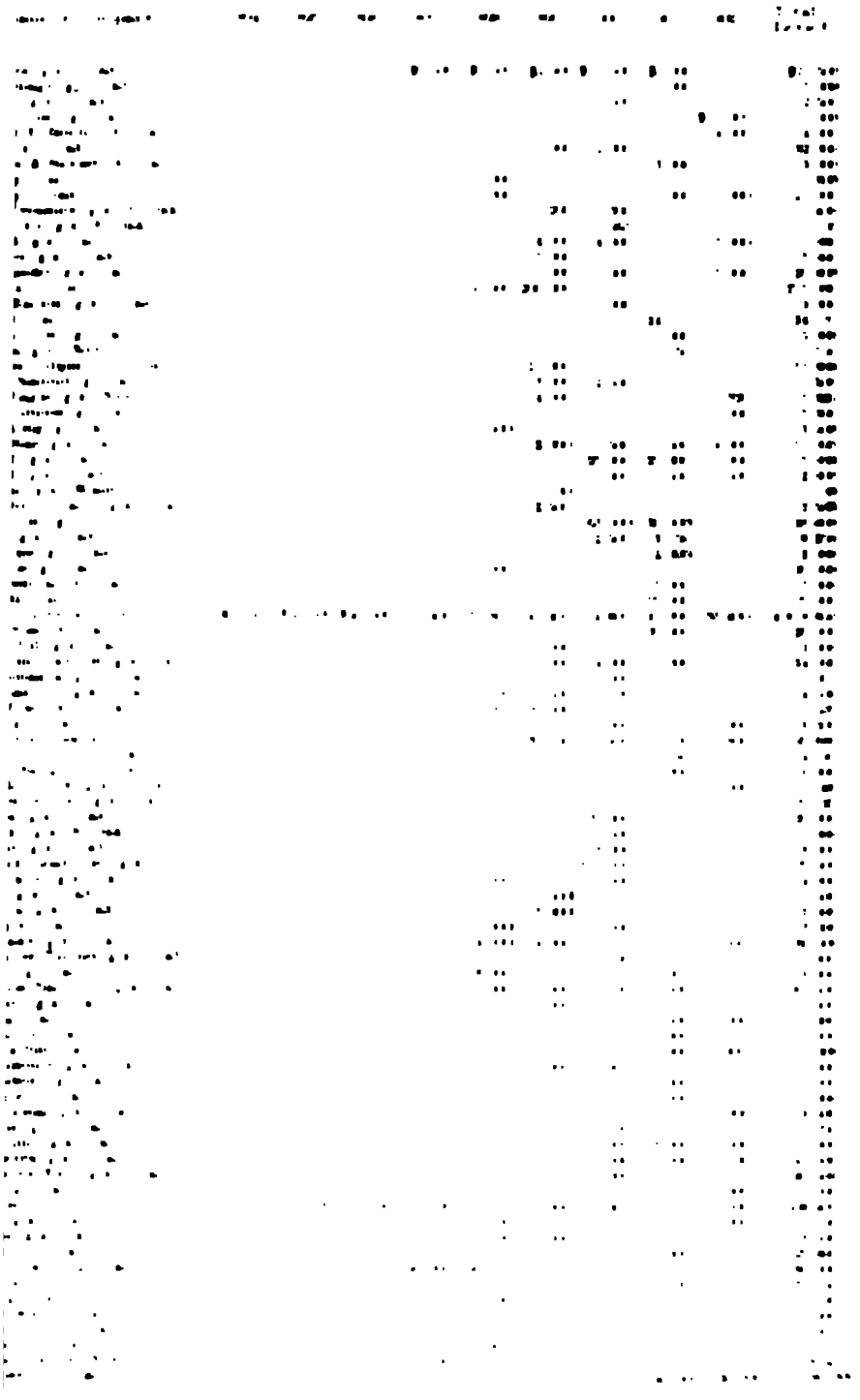
c., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

ASSESSMENTS LEVIED BY MINING COMPANIES



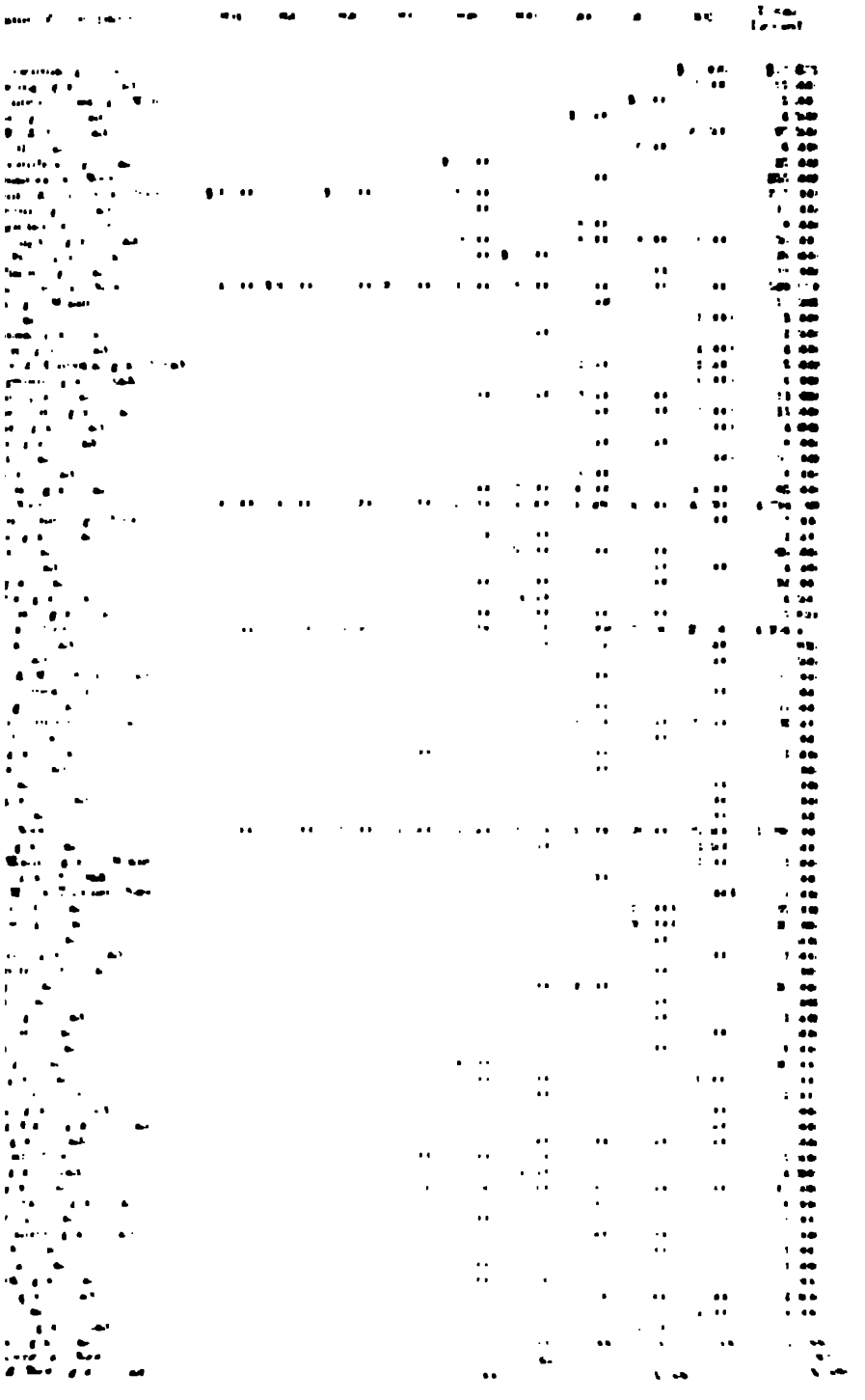
ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Canadian King, Wash.								$1,000		$1,000
Canton Placer, g., Cal.										25,000
Carb. & Rattler, g.s.l., Utah.									$24,000	24,000
Carbon Oil, Cal.										8,000
Caribou Oil, Cal.							$8,000	16,000		24,000
Carmelita Oil, Cal.								10,400	10,000	50,000
Cassa Oil, Cal.								2,000		2,000
Cedar Creek, g., Cal.					$2,000					2,000
Centennial, c., Mich.				120,000	300,000		270,000	180,000		910,000
Central Eureka, g., Cal.				20,000			12,000			32,000
Central Mammoth, g., Utah.							500			500
Century, g., Utah.									10,000	10,000
Century Oil, Cal.								8,600	5,500	22,100
Cerulean, g., Cal.								5,000		5,000
Challenge Con., s., Nev.	$50,000	$5,000	$7,500	50,00	1,000	$12,500	22,500	5,000	5,000	474,500
Champion, g., Cal.									17,000	107,500
Channel Bend, g., Cal.					2,000					2,000
Chicago, g.s.l., Utah.									2,500	2,500
Chicago & Mercur, g.s., Utah.						1,000		1,000		2,000
Chloride Queen, Idaho.								1,000		1,000
Chollar, s., Nev.	56,000	56,000	28,000	44 800	50,400	28,000	39,200	22,400	22,400	2,159,600
Christmas, g.s., Utah.						1,500	3,000			4,500
Church, g., Cal.					3,000					3,000
Cinnabar King, g., Cal.					1,000					1,000
Clarissa, g.s., Utah.						5,000	5,000			10,000
Cleveland, g., Utah.					2,000	1,000				3,000
Clyde Oil, Cal.								5,000		5,000
Coe, g., Cal.									25,000	25,000
Columbia, g.s., Utah.					750					750
Columbus Con., g.s., Cal.							2,000		3,000	5,000
Commonwealth, g., Utah.									2,500	2,500
Comstock, g. s. l., Utah.								20,000	30,000	50,000
Confidence, s., Nev.	6,240	14,976	7,488	14,976	13,728	8,736	9,984	99,984		568,930
Conglomerate, g.s., Utah.							6,250			6,250
Con. Cal. & Va., s., Nev.	108,000	54,000	118,800	108,000	108,000	108,000	97,200		54,000	997,200
Con. Gold G. & Sulp., Cal.									45,000	45,000
Con. Golden Trout, g., Cal.									25,000	25,000
Con. Imperial, s., Nev.		5,000	500	10,000	10,000	10,000	20,000	10,000	10,000	2,250,000
Con. New York, s., Nev.	5,000	10,000	5,000	60,000	30,000	3,000				186,500
Con. St. Gothard, g., Cal.					35,000	15,000		10,000		60,000
Constellation, g., Utah.							2,250	2,250		63,000
Contra Costa Coal, Cal.								30,000		30,000
Contra Costa Oil, Cal.								5,000		5,000
Copper Queen, Utah.									4,000	4,000
Corona Oil, Cal.								6,000		6,000
Crown Point, s., Nev.	65,000	25,000	70,000		25,000	20,000	15,000	15,000	20,000	3,040,000
Crusader Con., g.s.l., Utah.							5,000		2,500	7,500
Dalton, g.s.l., Utah.	5,000	5,000	5,000	2,500	7,500	5,000		5,000	7,500	71,250
Daylight, g., Utah.								2,000	5,000	7,000
Del Monte Oil, Cal.								20,000		20,000
Devil's Den Oil, Cal.								2,000		2,000
Dewey Gravel, g.s.l., Cal.							10,000			10,000
Dexter, g.s., Nev.					30,000					38,000
Diamond Con. g.s.l., Utah.						8,000		8,000		16,000
Diamond Creek, g., Cal.									20,000	20,000
Dreisam, g., Cal.						51,000	15,000			66,000
Dublin, g., Cal.								10,000	5,000	15,000
Dudley, g., Cal.									20,000	260,000
Dutch, g., Cal.						22,500	52,500			75,000
Eagle, g., Oregon.					3,000					3,000
East Honorine, g.s.l., Utah.									5,000	5,000
East Valeo, g., Utah.								5,000		5,000
Eldorado Oil, Cal.									10,000	10,000
Ella Eldon, g., S. Dak.								500		500
El Rey, g., Utah.							8,000			8,000
Elsie, g.s.l., Utah.									10,000	10,000
Ely, g., Utah.						2,000	3,000		2,000	7,000
Emerald, g.s., Utah.					3,000			1,500	10,750	15,250
Empire Oil, Cal.								14,000		14,000
Equality Oil, Cal.									10,000	10,000
Eureka Con., s., Nev.		12,500			10,000	5,000				512,000
Eureka Con. Drift, g., Cal.				75,000	5,000	15,000	17,500	10,000	5,000	228,000
Eureka-Swansea Ext., g.s., Utah.							5,000			5,000
Eutonia, s.l.g., Utah.							9,000	2,000	6,000	17,000
Excelsior Drift, g.s., Cal.					667	5,000	2,000			7,667
Exchange, g.s., Utah.							1,000	1,500		2,500
Exchequer, s., Nev.	10,000	5,000	5,000	5,000			3,000			738,000
Fall Creek, g., Cal.								10,000		10,000
Fall River, g.s., Cal.						2,500				2,500
Father de Smet, g.s., S. Dak.							25,000			225,000
Fifteen-Three Oil, Cal.									10,000	10,000
Fish Springs, g., Utah.							1,500			1,500
Florence, g.s., Utah.						1,000				1,000
Forlorn Hope, g., Cal.					20,000					20,000



ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

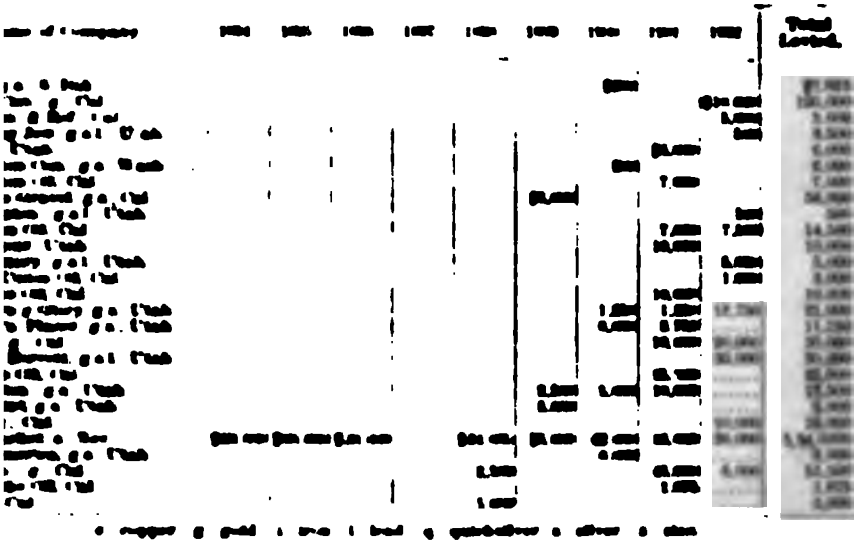
Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Kern Sunset Oil, Cal.								$2,000		$2,000
Keystone, g., Cal.									$3,000	3,000
Kings County Oil, Cal.								6,000		6,000
Lady Washington, s., Nev.			$5,400			$5,400			8,640	171,840
La Grange, g.s., Cal.						15,000				15,000
Laird, g., Cal.					$10,000					10,000
La Reine, g.s.l., Utah.									5,000	5,000
Larkin, g.s., Cal.					2,000	2,000	$4,000	10,000	12,000	40,000
La Suerte, g.s., Cal.					7,500	7,500	7,500	5,000	4,750	32,250
Laurel, g., Cal.									2,500	2,500
Leo, g., Mont.								2,500		2,500
Leon, g., Cal.					1,500					1,500
Linda Vista Oil, Cal.								11,460	3,000	14,460
Lion Con., g.s., Utah.						500	500			1,000
Little Bell, g., Utah.								37,500		37,500
Little Chief, g.s., Utah.						8,090	12,000	16,000	16,000	52,090
Little Jimmie, g.s.l., Utah.									1,875	1,875
Little Pittsburg, g.s., Utah.		$4,000	6,000	$4,000	4,000	5,000				23,000
Little Standard Oil, Cal.									10,000	10,000
Live Oak Con., g.s., Cal.					20,000	10,000	10,000		8,000	48,000
Live Yankee, g.s., Cal.					5,000	2,000				7,000
Lombard, g.c., Utah.								1,250		1,250
Los Angeles Oil, Cal.									5,000	5,000
Louis, S., g., Utah.								10,000		10,000
Lower Mammoth, g.s., Utah.					12,500	15,000	15,000			42,500
Lucky Bill, g.s., Utah.			7,200	6,600	1,800	2,500	2,400	12,000		72,000
Lulah Con., g.s., Utah.						1,500				1,500
Madeleine, g.s.l., Utah.									10,000	10,000
Madsen, g., Utah.								1,250	2,500	3,750
Mammoth, g.s., Nev.									2,000	2,000
Manhattan, g., Utah.								2,500	7,500	10,000
Mammoth Garfield, g.s., Cal.							17,500			17,500
Maple, g.s., Utah.								3,000	6,000	9,000
Maple Creek, g., Cal.								10,000		10,000
Marguerite, g.s., Cal.				20,000	15,000	15,000				65,000
Marina Marsicano, g.s., Cal.				16,360	19,000	19,000	7,000	1,000	24,000	86,360
Mariposa Com'l&M'g,g.s.,Cal.							50,000	50,000		210,000
Marmaduke, g.s., S. Dak.							500			500
Martha Washington,g.s.,Utah.					3,000	6,000	6,000	9,000	15,000	39,000
Martin White, s., Nev.	$25,000					120,000				1,200,000
Maxfield, g.s., Utah.					6,000	9,000	9,000			24,000
Mayday, g.s., Cal.					5,000	10,000	5,000	2,500	1,500	24,000
Mayday, g.s., Utah.					2,000	2,000				4,000
Mayflower, g.s., Utah.							2,000	5,000	5,000	12,000
Mayflower Gravel, g.s., Cal.					6,000		7,500	6,000		19,500
Mazeppa, g.s., Cal.							5,000		2,000	7,000
McKinley, g., Utah.								1,250		1,250
McKittrick, Con., Oil, Cal.							18,000	18,000		36,000
McKittrick Oil, Cal.								15,000	6,000	21,000
Melcher, g.s., Utah.							1,000	625	1,375	3,000
Menlo, g., Cal.									6,000	6,000
Mercantile Crude Oil, Cal.									5,000	5,000
Merrimac, g., Cal.					20,000					20,000
Meteor, g.s., Utah.					3,734	4,900	2,997	1,980		13,630
Mexican, s., Nev.	75,000	75,000	40,320	20,000	40,320	25,200	45,360	50,400	30,240	2,440,160
Midland, g.s., Utah.							3,000			3,000
Midnight Bowers, g.s., Utah.						1,000	1,000			2,000
Minnehaha Oil, Cal.								10,000		10,000
Minnie, g., Utah.									1,000	1,000
Mistletoe, g., Cal.									10,000	10,000
Mohican g., Cal.								10,000	5,000	15,000
Molly Bawn, g.s., Utah.						1,000				1,000
Montecito, g., Cal.					10,000					10,000
Monte Cristo, g.s., Utah.									2,500	2,500
Montreal, g.s., Utah.		375		375		25,000				25,750
Mooney Con., g.s., Cal.							20,000			20,000
Morgan, g., Cal.					10,000					10,000
Morning Glory, g., Wash.									3,000	3,000
Mountaineer, g.s., Cal.					15,000		25,000			40,000
Mountain Lake, g.s.l., Utah.									5,000	5,000
Mountain View, g., Cal.								15,000		15,000
Mt. Blanc Con., g., Cal.								1,250		1,250
Mt. Diablo Oil, Cal.								10,000	5,000	65,000
Nancy Hanks, g., Cal.					5,000					5,000
Nashville, g., Cal.					2,000					2,000
National Con., g.s., Cal.					15,000	45,000	15,000	10,000	5,000	92,000
Navajo, g.s., Utah.								2,500		2,500
Nevada, s., Nev.							10,000			10,000
Nevada, c., Utah.									5,000	5,000
New Century Oil, Cal.								15,000		15,000
New Erie, g.s., Utah.						2,000	500	7,500	500	10,500
New Imperial, g.s., Utah.						1,000				1,000
New Klondike, g.s., Utah.						2,961	235			3,196
New La Plata, g.s., S. Dak.							500			1,700
New Mercur, g.s., Utah.									4,200	4,200



ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied
Sam Houston, g.s., Cal.									$4,000	$4,000
Sampson, g.s.l., Utah									10,000	10,000
San Pablo Oil, Cal.									5,000	5,000
Santa Rosalia, q., Mex.							$5,000			5,000
Savage, s., Nev.	100,805	$67,200	$67,200	$67,200	$44,800	$22,400	33,600	$22,400		7,205,000
Scorpion, s., Nev.	5,000			5,000			3,000			403,000
Sea Breeze Oil, Cal.								20,000		20,000
Sea Swan, g., Utah								2,500		2,500
Sag. Belch. & Mides, s., Nev.	20,000	30,000	10,000	10,000	8,000	10,000	6,000	6,000	2,000	302,000
Sharp, g., Utah								5,000		5,000
Shasta Oil, Cal.								20,000		20,000
Sheba, g.s., Cal.							10,000			10,000
Sheep Rock, g.s., Utah				5,250			32,500			37,750
Shenandoah Con., g., Cal.								4,000		4,000
Shoebridge Bonanza, g.s., Utah							2,000	4,000		13,000
Shower Con., g.s., Utah						6,000	2,000	24,000	12,000	48,000
Sierra Nevada, s., Nev.	50,000	50,000	50,000	40,000	20,000	50,000	45,000	50,000	30,000	6,992,000
Sierra Union W'r & Mg., Cal.									25,000	25,000
Silver Bell, s., Mont.					5,000					5,000
Silver Bow, g.s., Utah							5,000	7,500	5,000	17,500
Silver Cloud, g.s., Utah						5,000		2,500		7,500
Silver Hill, s., Nev.	5,000			5,000	5,000					2,250,000
Silver King, g.s., Ariz.	100,000		75,000	50,000	50,000	50,000	25,000	25,000	15,000	350,000
Silver Park, g.s., Utah							9,000			9,000
Silver Queen, g.s., Utah							1,000			1,000
Silver Shield, g., Utah								1,000	2,000	3,000
Silver State, g.s., Utah				1,000			500		2,500	4,000
Siskiyou Con., g.s., Cal.	14,000	4,000	2,000		3,000	3,000	6,000			55,000
Skagit Cumb. Coal, Wash.							7,500	22,500		29,500
Skylark, c., Utah								5,000	7,500	12,500
Snow Flake, g.s., Utah					2,000	5,000	2,000	7,000	10,000	28,500
Snowstorm, g.s., Utah								2,500		2,500
Sonora, g., Cal.							5,000	4,000	8,000	17,000
Sonora Quartz, g.s., Mex.							5,000		10,000	5,000
South Bingham, g.s., Utah						2,500	2,500			5,000
South Eureka, g.s., Cal.						6,000			3,000	9,000
South Fork Con., g.s., Utah					5,000					5,000
So. Queen, g.s.l., Utah									1,250	1,250
South Paloma, g.s., Cal.							1,200			1,200
South Lily, g.s.l., Utah									500	2,000
South Sliger, g., Cal.								10,000		10,000
Spanish Bar, g.s., Cal.					2,000	5,000	11,000	5,000		23,000
Spence Mineral, Cal.									6,000	6,000
Springfield, g.s.l., Utah.									5,000	5,000
Star, g.s., Utah.					5,000	30,000	25,000		7,500	67,500
Sterling, g., Cal.					15,000					15,000
Stockton, g.s.l., Utah.									5,000	5,000
Success, g.s., Utah						9,750	3,000			12,750
Sumdum, g., Alaska.									25,000	25,000
Sumdum Chief, g., Alaska.									25,000	25,000
Sunbeam Con., g.s., Utah.				11,250	5,000	50,000	55,000			131,388
Sunrise, g.s.l., Utah.									750	750
Sunset District Oil, Cal.								7,500		7,500
Superior Oil, Cal.								4,600		4,600
Sweet Vengeance, g.s., Cal.							10,000			150,000
Tanama, g.s., Cal.						10,000		30,000	10,000	50,000
Teeora, g.s., Utah.							2,750	80,000		102,000
Tetro, g.s., Utah.					18,000	15,000	15,000	27,000	12,000	90,500
Texas, g.s., Cal.						15,000	30,000	10,000		55,000
Thorpe, g.s., Cal.					5,000	5,000				10,000
Tintic, g.s., Utah.						4,375				4,375
Tintic Copper King, Utah.									2,500	2,500
Tomboy, g., Utah.							5,000		2,500	7,500
Tracy, g.s., Cal.						5,000				5,000
Trent, g., So. Dak.								1,500		7,500
Troy, g.s., Alaska.				2,000	6,250	6,250				16,750
Tule Belle, g., Cal.								10,000		10,000
Tuscarora Chief, g.s., Utah.						2,000				2,000
Twentieth Cen., g.s.l., Utah.									1,250	2,500
Uklah Oil, Cal.								10,000		10,000
Ultimo, g., Cal.									30,000	30,000
Uncle Sam, g.s.l., Utah.									6,000	6,000
Union Con., s., Nev.	35,000	20,000	40,000	20,000	30,000	18,000	30,000	25,000	30,000	2,745,000
United Sunbeam, g., Utah.								30,000	30,000	30,000
U. S. Grant, g.s., S. Dak.							1,000			4,500
Usona Oil, Cal.									1,000	1,000
Utah Con., s., Nev.	5,000	5,000	10,000	30,000	20,000	15,000	15,000	20,000	20,000	540,000
Utah-Wyoming Oil, Utah.									2,500	2,500
Uyak Bay, g., Alaska.									3,000	3,000
Valeo, g.s., Utah.						10,000	10,000			20,000
Vallejo, q., Cal.					2,000	2,000				4,000
Valley View Oil, Cal.								17,500		17,500
Vernon Oil, Cal.								25,000		25,000
Victor, g.s., Utah.				$75				15,000	15,000	8,575
Victoria, g.s., Utah								4,000		4,000

ASSESSMENTS LEVIED BY MINING COMPANIES. *Concluded.*



AUSTRIA-HUNGARY.

THE latest official statistics of the mineral production, imports, and exports of Austria-Hungary are summarized in the following tables:

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND DOLLARS; 5 CROWNS=$1.)

Year.	Alum.		Alum and Pyritous Shale.		Antimony.		Antimony Ore.		Asphaltic Rock.		Bismuth Ore.		Coal.	
1897	851	$23,164	21,585	$7,178	425	$45,292	864	$29,379	300	$3,547	1	.....	10,492,771	$15,361,946
1898	1,037	29,126	28,914	8,547	343	46,694	679	22,867	643	6,243	*Nil.*	.....	10,347,522	21,895,044
1899	604	16,713	19,879	6,711	271	33,693	410	15,344	2,635	15,134	0·3	$280	11,455,139	22,910,277
1900	620	18,426	3,004	3,608	153	14,844	201	7,065	887	9,608	4·0	2,558	10,992,545	19,118,184
1901	442	12,906	2,551	3,916	114	10,433	126	7,557	541	7,742	16·0	4,000	11,736,840	21,981,231

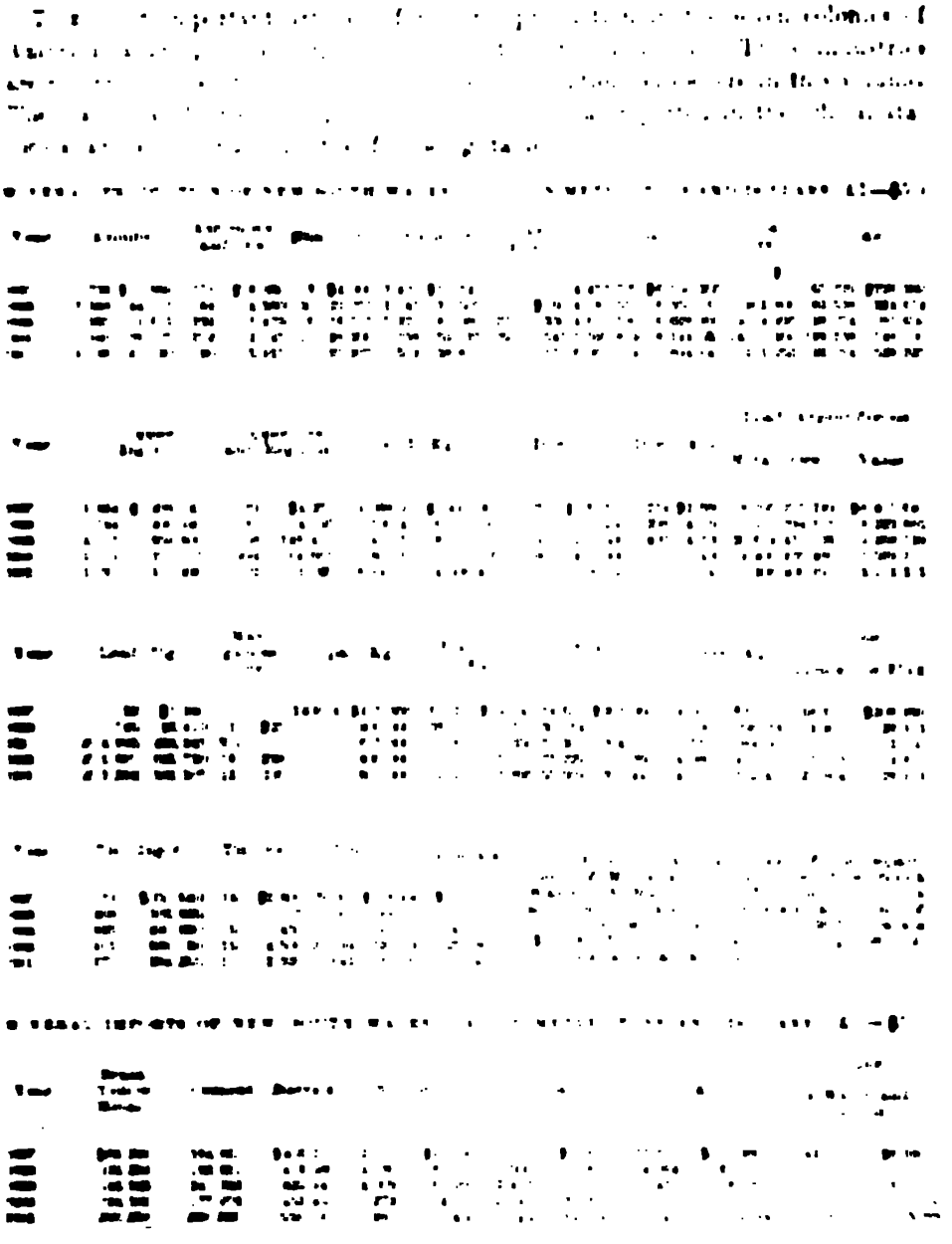
Year.	Coal, Lignite.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.		Gold—Kg.		Gold Ore	
1897	20,458,093	$16,033,769	1,083	$245,874	125	$1,254	7,405	$111,757	276	$23,204	67·6	$37,470	647	$13,175
1898	21,083,361	17,397,116	1,041	251,124	360	4,526	6,791	101,399	209	18,864	71·5	40,800	448	21,950
1899	21,751,794	19,033,493	1,123	368,417	475	3,907	6,731	96,601	235	20,295	75·7	37,746	387	12,408
1900	21,539,917	22,526,715	881	307,693	474	4,401	5,825	95,699	234	25,299	70·9	34,107	227	8,566
1901	22,473,510	25,037,512	776	254,347	472	4,438	7,406	119,241	256	26,727	46·6	20,007	143	6,363

Year.	Graphite.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.		Litharge.	
1897	38,504	$541,058	1,613,876	$1,506,419	762,685	$10,650,493	9,680	$630,484	14,145	$464,760	1,626	$106,398
1898	33,062	349,426	1,733,649	1,691,075	837,767	11,805,345	10,340	715,805	14,363	492,156	1,590	112,280
1899	31,819	395,280	1,725,143	1,968,261	872,352	13,342,588	9,736	748,978	12,820	509,732	1,525	117,132
1900	33,663	418,126	1,894,458	2,219,599	879,132	14,194,844	10,650	944,431	14,314	607,887	1,298	116,687
1901	29,992	363,702	1,963,246	2,310,428	884,844	13,374,003	10,161	727,085	16,688	548,810	1,317	109,088

Year.	Manganese Ore.		Mineral Paint.		Nickel and Cobalt Products(*b*)		Petroleum.		Quicksilver		Quicksilver Ore		Salt.	
1897	6,012	$19,184	3,653	$33,620	37·6	$10,022	275,204	$2,350,677	532	$476,048	88,298	$335,624	331,084	$10,224,576
1898	6,132	19,118	3,213	29,757	58·8	10,800	323,142	3,284,776	491	459,415	86,519	320,430	341,959	10,607,729
1899	5,411	18,239	2,055	24,567	38·1	8,572	309,590	3,185,541	536	492,021	92,323	354,946	342,059	10,134,760
1900	8,804	27,390	2,828	31,547	31·2	6,884	347,213	4,222,715	510	499,052	94,727	371,723	330,277	9,957,173
1901	7,796	25,466	1,701	26,743	20·5	2,998	404,662	4,602,118	525	547,513	97,360	392,705	333,238	9,866,231

Year.	Silver—Kg.		Silver Ore.		Sulphuric Acid.		Sulphur, Crude Rock		Tin.		Tin Ore.		Tungsten Ore.	
1897	40,026	$780,965	20,628	$748,720	8,515	$80,422	530	$1,935	48	$16,806	16	$969	31	$7,699
1898	40,304	754,022	20,886	705,038	7,003	63,769	496	1,661	48	18,829	13	758	36	13,333
1899	39,564	761,978	21,554	742,922	7,814	63,045	555	1,526	41	24,639	54	551	50	22,259
1900	39,572	781,519	21,641	759,299	7,067	46,970	862	2,956	40	27,651	51	1,966	50	14,010
1901	40,205	781,045	21,363	731,487	7,073	45,453	4,911	12,107	49	30,264	43	1,505	45	10,749

AUSTRALASIA



Year.	Copper—Continued.					Gold.		Iron and Steel.					
	Ingot.		Ore.		Rod, Sheet, and Wire.	Coin.	Bullion and Ores.	Pig.		Ore.		Manufactures. (c)	
1897....	6	$1,585	1,401	$92,440	$96,445	$5,749,095	$10,328,540	16,256	$269,470	1,293	$8,095	71,469	$3,994,103
1898....	3	1,000	1,013	40,245	61,635	18,323,980	9,779,270	12,081	189,895	2,038	8,585	65,140	3,681,285
1899....	43	11,560	9,209	346,500	135,370	3,510,800	12,908,535	9,153	168,995	4,205	14,615	69,957	5,224,515
1900....	35	12,400	7,076	266,470	299,605	7,212,835	15,357,095	13,280	233,130	6,350	20,545	88,198	6,202,685
1901....	4	1,670	3,577	164,320	347,690	6,328,900	13,372,410	9,649	186,040	4,252	2,280	96,816	5,704,380

Year.	Lead.				Nickel Ore.		Petroleum, Refined. *Liters.*		Potassium Salts. Nitrate.		Quicksilver. *Flasks.*	
	Pig.		Pipe, Sheet and Old.									
1897....	5,281	$289,500	908	$80,235	208	$5,000	11,027,291	$492,275	176	$18,455	470	$12,925
1898....	2,379	135,230	49	3,685	788	7,575	13,723,963	563,690	181	17,170	469	17,005
1899....	1,963	125,580	75	6,145	(b)	.....	17,335,661	883,255	114	11,115	398	17,910
1900....	5,787	444,560	29	3,705	508	10,300	16,897,924	907,900	122	13,563	228	10,465
1901....	2,731	165,190	67	6,385	(b)	.....	30,844,110	138,383	136	13,795	290	12,225

Year.	Salt.				Silver.								Slate.	
	Rock.		Brine. *Bags.*		Coin.	Ingot—Kg.		In Matte—Kg.		Ore.			Roofing—*Number*	
1897....	4,654	$34,110	36,722	$261,290	$181,630	288	$5,060	1,928	$35,500	1,298	$38,680		1,908,475	$78,980
1898....	6,647	59,220	30,991	217,115	286,010	267	4,980	.....	.....	964	37,625		1,883,871	90,340
1899....	7,987	46,480	34,537	231,740	354,185	299	5,975	1,045	18,715	3,070	95,045		2,885,637	113,600
1900....	3,662	23,190	28,905	210,790	810,480	342	6,955	132	2,370	1,880	83,445		2,350,980	96,025
1901....	5,758	35,930	29,782	231,160	494,600	87	1,645	438	8,800	1,648	121,670		2,092,790	77,315

Year.	Slate—Cont'd.		Sodium Salts.								Stone, Excepting Marble.
	Slabs. *Number.*		Bicarbonate.		Carbonate. (Crude.)		Carbonate. (Crystals.)		Hydrate. (Caustic.)		
1897....	2,605	$8,575	788	$31,395	1,452	$50,583	495	$7,940	1,218	$66,900	$27,005
1898....	3,482	12,420	953	36,495	1,469	38,905	468	13,440	1,241	63,225	30,225
1899....	5,307	13,135	1,200	39,080	1,716	42,525	566	19,375	1,209	61,680	31,065
1900....	10,176	20,220	979	32,475	1,341	39,755	185	5,180	1,492	81,705	46,520
1901....	3,258	9,565	845	27,165	1,957	65,885	116	3,300	1,426	88,065	41,985

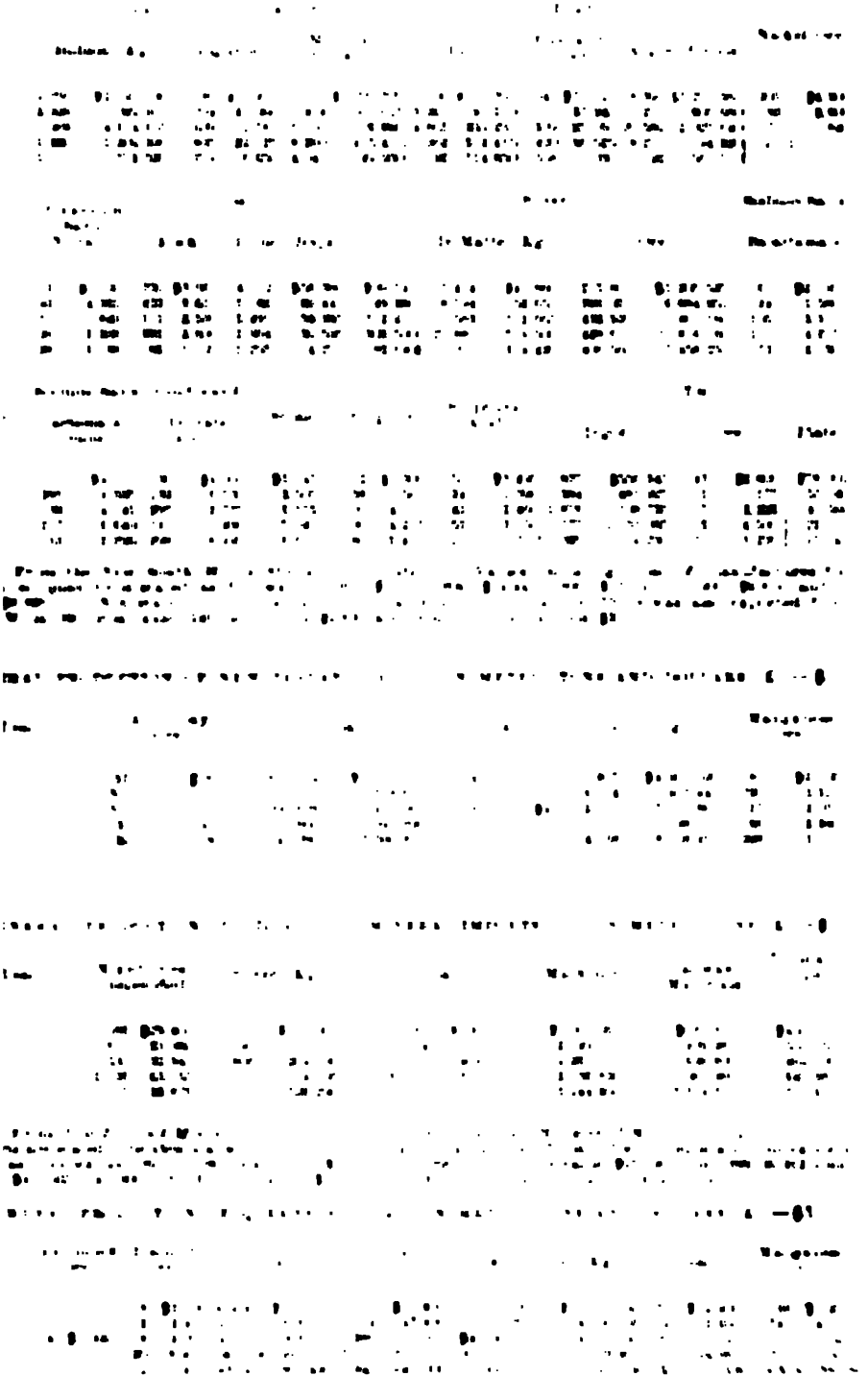
Year.	Sulphur.		Tin.				Zinc.			
			Ingot.		Ore.		Plates.	Slabs.		Sheet and Manufactures.	
1897....	2,997	$33,955	698	$305,135	662	$104,510	$300,350	1,341	$122,815	561	$58,010
1898....	1,845	26,960	478	161,245	554	92,665	373,060	1,220	122,225	377	43,905
1899....	1,575	23,575	681	396,095	868	262,455	258,035	724	90,730	225	25,005
1900....	2,208	56,510	299	195,205	741	254,710	643,940	1,084	122,225	514	73,000
1901....	869	24,910	166	100,415	876	297,315	498,780	1,175	111,445	414	52,925

(a) From the *New South Wales Statistical Register*. (b) Not stated in the reports. (c) In addition there were imports of manufactures for which no weights are stated; in 1897, $68,495; 1898, $136,640; 1899, $88,690; in 1900, $96,905; and in 1901, $79,060.

MINERAL EXPORTS OF NEW SOUTH WALES. (a) (e) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony.						Bismuth Ore.	Cement. *Barrels.*		Chrome Ore.		Coal.		Cobalt Ore.	
	Ore.		Auriferous.		Metal.										
1897..	49	$2,510	21	$1,500	102	$14,050	d3·3	$4,150	15,272	$39,185	5,959	$101,320	2,739,709	$4,760,270	73	$2,500
1898..	57	2,150	13	795	13	1,570	31·5	23,775	16,801	45,420	6,924	122,775	2,888,465	4,813,340	184	4,450
1899..	314	11,690	18	1,650	1	20	15·8	16,775	12,297	36,030	9,795	167,980	2,843,310	5,028,970	347	11,085
1900..	258	12,680	(c)	.....	1	175	7·3	9,785	9,967	26,680	3,618	63,635	3,494,366	6,365,170	148	5,000
1901..	88	5,725	(c)	.....	2	405	15·1	18,140	4,742	13,485	2,907	45,770	3,536,521	8,409,120	112	5,255

Year.	Coke.		Copper.						Gold.	
			Ingot.		In Matte.		Ore.		Rod, Sheet, Wire.	Ore.	Coin.
1897....	32,221	$135,225	4,126	$964,880	2,778	$549,440	169	$4,255	$5,770	222,040	$21,733,525
1898....	31,284	125,330	5,226	1,225,715	480	114,765	181	4,195	12,950	227,410	32,645,260
1899....	43,706	181,980	5,532	1,956,700	1,163	387,660	493	17,710	21,945	13,970	17,444,420
1900....	75,598	302,755	6,771	2,341,985	696	139,195	997	35,470	13,995	13,705	32,940,110
1901....	79,382	298,905	6,275	2,079,810	477	124,755	650	28,385	14,015	10,995	30,257,760



Year.	Opal.	Silver Ore.		Silver—Kg.		Stone. Building. (b)		Tin Ore.		Tungsten Ore	
							$				
1898.....	$33,225	3	$52,925	3,235	$52,925	(c)	.....	1,041	$182,510	79	$13,700
1899.....	45,000	5	78,355	4,521	78,355	164,939	112,330	1,322	266,510	263	50,100
1900.....	37,500	4	63,560	3,514	63,560	152,484	107,585	1,133	370,305	198	33,085
1901.....	37,000	18	311,205	17,777	311,205	(c)	.....	1,668	468,615	73	5,725
1902.....	35,000	(c)	.....	21,813	350,725	(c)	.....	2,118	580,855	56	5,895

MINERAL IMPORTS OF QUEENSLAND. (d) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Cement and Plaster of Paris—*Barrels.*		Coal.		Coke.		Glass and Glassware.	Gold Bullion—Kg.	
1897.....	65,230	$159,375	21,624	$98,370	61	$505	$108,060	176·9	$91,490
1898.....	56,441	143,425	23,281	99,125	199	1,290	217,015	198·0	115,695
1899.....	86,986	223,735	33,863	135,825	*Nil.*	.....	164,395	306·4	172,980
1900.....	70,217	183,595	31,592	150,315	57	250	295,470	81·0	49,645
1901.....	44,097	112,515	26,155	120,630	5,657	24,355	251,695	85·2	47,110

Year.	Gold Specie.	Iron and Steel.		Petroleum—*Gallons.*		Silver Bullion. Kg.		Silver Specie.
		Rails, Track Material.	All other.					
1897.....	$59,350	$121,950	$1,586,605	1,369,178	$278,070	11·1	$265	$112,145
1898.....	1,330,500	440,590	1,761,220	1,928,311	329,955	26·8	375	54,640
1899.....	818,000	385,360	2,600,860	1,867,755	357,495	8·6	175	152,655
1900.....	1,660,225	1,219,815	2,453,350	1,584,217	347,410	3·8	95	141,325
1901.....	1,094,000	646,475	1,961,735	1,964,991	419,895	9·4	240	62,760

MINERAL EXPORTS OF QUEENSLAND. (a) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Antimony Ore.		Bismuth Ore.		Copper.								Gold—Kg.		Gold Ore.	
					Ore.		Ingot.		Matte.		Regulus.					
1897..	25	$2,500	39	$20,150	241	$15,425	196	$34,515	150	$21,925	143	$35,075	25,293	$12,843,510	230	$19,895
1898..	9	300	6	1,710	375	28,845	(c)	.....	5	1,325	2	1,940	29,390	14,278,905	748	75,790
1899..	15	2,110	2	1,755	737	54,620	4	1,070	104	22,405	137	34,660	31,656	14,574,950	513	47,495
1900..	11	1,575	5	5,135	1,970	176,150	(c)	.....	57	14,245	77	32,000	29,307	14,000,365	762	97,110
1901..	20	1,000	37	18,200	2,028	259,050	(c)	.....	3,021	643,005	32	1,450	25,607	12,794,800	887	127,310
1902..	.....	.....	.....	.....	2,268	256,270	59	14,640	4,486	761,020	1	200	27,546	13,521,800	705	97,430

Year.	Precious Stones	Silver.						Tin Ore.		Tin.		Tungsten Ore.	
		Ore.		Silver-Lead Bullion.		Doré Bullion.—Kg.							
1897.....	$5,700	259	$35,080	301	$37,350	1,823	$210,565	636	$115,750	151	$675	(c).....	
1898.....	7,735	207	39,370	(c)	.....	1,951	206,065	535	103,455	150	55,900	2	$120
1899.....	11,950	332	54,686	4	875	1,930	173,945	709	221,615	358	198,180	371	121,080
1900.....	660	61	9,260	15	3,050	1,047	159,780	596	209,075	283	190,715	238	69,765
1901.....	1,765	506	48,255	.....	2,160	1,488	207,305	808	287,275	485	308,230	76	8,760
1902.....	2,745	31	6,630	.....	2,195	2,078	429,045	774	258,115	677	299,375	125	19,295

(a) From *Annual Reports of the Under Secretary of Mines*, Queensland, when not otherwise stated. (b) From *Mineral Statistics of the United Kingdom.* (c) Not reported. (d) From *Statistical Abstracts for the Several Colonial and other Possessions of the United Kingdom.*

MINERAL IMPORTS OF SOUTH AUSTRALIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Coal.		Coke.		Gold and Silver Bullion and Specie.	Iron.				Silver-Lead.			
						Bar, Sheet, Hoop, and Rod.		Galvanized, Plain, and Corrugated.		Metal.		Ore.	
1897..	378,495	$1 012,140	75,205	$402,690	$78,340	6,505	$239,970	6,438	$454,750	17,466	$2,989,810	801,980	$5,221,195
1898..	420,001	1,121,795	82,796	428,705	47,685	10,076	287,500	6,627	501,945	3,455	691,885	415,851	6,255,645
1899..	444,539	1,223,595	54,166	313,145	963,920	6,023	216,605	6,363	523,475	208	59,750	480,104	6,631,495
1900..	508,769	1,530,605	72,947	458,675	494,120	5,726	270,705	7,555	732,150	(c)	.....	571,598	11,493,075
1901..	483,811	1,425,230	64,254	383,380	595,278	5,471	221,630	5,577	462,080	(c)	.....	341,774	7,753·6 0

(a) From British Statistical Abstracts. (c) Not reported.

Year.	Barytes, Including Manufactured Product.		Brass, German Silver and Tombac. Crude, Old and Remnants.		Brass, German Silver and Tombac. Bars, Sheets, Wires, Etc.		Cement.		Chloride of Lime.	
1897.....	70	$2,923	1,699	$284,197	680	$269,856	19,796	$112,536	111	$3,552
1898.....	111	3,690	1,879	339,764	889	351,178	23,989	135,861	113	3,606
1899.....	65	1,161	1,824	421,037	910	378,314	38,193	198,606	203	6,490
1900.....	23	429	1,811	422,088	1,256	601,749	46,761	243,156	193	6,128
1901.....	55	1,000	2,006	466,800	1,054	521,800	44,723	232,600	736	20,600

Year.	Chrome Ore.		Clay Products. Manufactures.		Clay Products. Kaolin and Feldspar.		Clay Products. Potters' and Other Clays.		Coal.	
1897.....	153	$3,682	55,895	$3,280,000	68,609	$918,756	46,968	$187,872	701,919	$2,133,251
1898.....	121	2,653	66,005	3,404,400	74,008	991,308	52,851	211,403	894,730	2,687,796
1899.....	53	1,052	72,104	3,524,200	78,557	1,055,430	61,898	247,594	879,236	2,823,766
1900.....	22	460	75,672	3,835,400	108,178	1,009,855	66,869	168,138	815,097	2,902,527
1901.....	62	1,200	62,916	3,946,000	97,087	947,400	57,571	146,400	748,802	2,760,000

Year.	Coal, Lignite.		Coke.		Copper. Ore.		Copper. Crude and Old.		Copper. Bars, Sheets, Plates, etc.		Copper Sulphate.	
1897.....	8,108,975	$10,742,872	145,056	$790,594	0·1	$3	159	$38,232	180	$58,991	14	$1,305
1898.....	8,351,955	11,749,110	194,289	1,095,885	12	476	173	44,998	266	91,469	29	2,655
1899.....	8,662,788	12,879,387	252,971	1,481,120	74	3,690	534	190,933	998	133,547	66	7,980
1900.....	7,864,409	13,911,967	262,793	1,707,563	801	41,636	471	169,560	200	92,152	57	7,081
1901.....	8,076,575	16,249,000	303,651	2,142,400	1,042	61,400	435	148,000	334	139,800	23	2,600

Year.	Copperas.		Cryolite.		Fertilizers, Mineral.		Fluorspar.		Glass. Manufactures.		Glass. Remnants.	
1897.....	648	$6,870	10	$2,044	4,498	$44,979	27	$385	50,082	$8,948,000	2,086	$14,599
1898.....	589	4,744	23	4,602	4,267	42,673	22	227	50,304	8,699,600	1,904	13,326
1899.....	808	6,384	101	22,086	3,419	27,350	335	3,087	55,539	9,978,800	2,772	19,408
1900.....	748	5,986	237	34,964	3,661	29,284	52	451	57,190	10,582,000	5,583	39,016
1901.....	548	5,000	231	33,200	5,278	42,200	30	400	55,358	9,823,000	2,024	14,200

Year.	Gold. Ore.		Gold. Bullion—Kg.		Gold. Old, Remnants, and Dross—Kg		Gold. Coin—Kg.		Graphite.		Gypsum. Crude.	
1897.....	37	$2,214	239	$110,896	119,336	$352,510	33,316	$18,394,070	14,229	$228,598	662	$2,914
1898.....	13	810	27	12,528	137,478	371,760	42,620	23,428,432	17,109	252,235	718	3,160
1899.....	67	6,336	38	17,632	163,160	308,800	23,770	12,523,500	19,451	283,771	633	2,787
1900.....	1	96	298	119,200	132,690	312,220	20,628	11,411,409	18,996	296,643	502	1,506
1901.....	0·2	.....	100	41,800	149,800	347,200	12,300	6,779,200	14,900	238,600	461	1,200

Year.	Gypsum.—Con. Calcined.		Hydrochloric Acid.		Iron. Ore.		Iron. Pig, Old, etc.		Iron. Manufactures.		Iron and Steel. Bars, Sheets, Wire, etc.	
1897.....	1,804	$15,875	1,439	$12,089	247,856	$941,852	12,084	$243,600	21,064	$4,362,400	17,387	$1,296,800
1898.....	2,163	19,089	1,614	13,884	302,317	1,269,790	15,803	261,200	22,724	4,958,000	23,231	1,601,200
1899.....	1,539	12,310	1,495	12,706	326,951	1,503,976	27,738	508,400	35,299	5,241,200	45,720	2,373,800
1900.....	1,723	13,787	1,659	17,090	263,421	1,211,738	53,426	1,141,000	48,368	6,037,200	56,995	3,958,800
1901.....	1,206	9,600	1,632	16,400	229,624	1,056,200	23,630	441,800	46,619	5,845,200	31,404	1,840,800

Year.	Lead. Ash.		Lead. Litharge.		Lead. Metal and Alloys.		Lead. Ore.		Lead. Red and Yellow		Lead. White.		Lime. (Hydraulic and Caustic.)	
1897.....	114	$3,181	355	$28,376	241	$15,863	2,438	$78,022	24	$2,008	47	$6,317	83,110	$379,166
1898.....	100	3,209	188	16,579	545	56,300	2,253	81,122	45	4,132	55	7,796	99,067	407,569
1899.....	99	3,259	188	16,000	258	21,058	2,502	110,070	45	4,103	40	5,711	85,570	359,486
1900.....	66	2,244	242	22,245	393	35,095	2,628	99,860	21	1,955	34	4,910	86,273	379,599
1901.....	112	2,600	179	14,200	68	4,800	4,143	111,800	32	2,800	22	2,600	82,398	362,400

MINERAL EXPORTS OF TASMANIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Bismuth Ore.		Coal and Coke.		Copper Ore.		Copper, Blister.		Glassware, including Earthenware.	Gold. Ore.		Gold. Bullion—Kg.		Coin.
1897..	(b)	.....	2,271	3,095	58	$4,560	4,595	$1,825,595	$780	621·6	$19,970	1,989	$1,132,469	(b)
1898..	4	$560	2,695	3,290	487	20,660	5,092	1,954,165	(b)	1,054·9	19,085	1,581	894,385	$25,000
1899..	6	4,500	2,799	6,005	1,756	119,125	8,575	3,600,275	(b)	545·6	33,595	1,646	1,086,173	(b)
1900..	(b)	.....	2,782	5,150	4,290	317,965	9,342	4,120,355	(b)	305	1,600	1,729	1,052,720	(b)
1901..	(b)	.....	29	85	10,180	749,580	9,906	4,388,160	950	288·9	38,345	1,725	1,059,900	(b)

Year.	Iron. Old Metal.		Iron. Rails.		Iron Oxide.		Lead.		Silver. Ore.		Silver. Bullion.		Tin. Ore.	
1897....	198	$1,490	97	$80	(b)	.....	19·3	$725	19,888	$1,094,385	(b)	.....	5	$2,280
1898....	117	1,295	(b)	.....	20	$110	(b)	.....	14,168	779,5[illegible]	(b)	.....	6	835
1899....	98	745	(b)	.....	6	30	5	250	13,618	742,990	1,458	82[illegible]	58	18,120
1900....	(b)	.....	(b)	.....	(b)	.....	5·5	415	12,397	680,830	2,[illegible]	3[illegible]	13	3,195
1901....	298	2,970	(b)	.....	1	50	5·6	315	15,294	944,645	4,164	6[illegible]	80	18,220

Year.	Tin.—Continued. Metal.		Zinc.	
1897....	2,462	$749,970	42	$1,890
1898....	2,695	705,810	6	265
1899....	2,278	1,391,615	8	660
1900....	2,092	1,349,165	27	1,595
1901....	1,818	1,092,710	2	50

(a) From *Statistics of the Colony of Tasmania*. Additional exports in 1897: Jewelry and plate, $6,165; silver coin, $12,875; unclassified ore, 30 metric tons, $1,450; mineral sand, ½ metric ton, $5; copper metal, 1½ tons, $40; iron ore, 204 tons, $4,015; manganese ore, 2 tons, $30; mineral oxide, 5 tons, $45; in 1898: Jewelry and plate, $8,395; iron ore, 1,735 tons, $8,540; in 1899: Asbestic, 208 tons, $1,815; tin plates, $2,150; iron ore, 3,635 tons, $17,350, in 1901, asbestic, 47 tons, $225; iron ore, 622 tons, $2,595. (b) Not stated in the reports.

MINERAL PRODUCTION OF VICTORIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Antimony Ore.		Coal.		Lignite.		Copper Ore		Gold—Kg. (b)		Lead Ore, Argentif.		Slate and Flagging.		Tin Ore.	
1897..	5	$100	240,057	$543,200	4,494	$6,885	(d)	.....	25,280	$16,255,320	(d)	.....	(d)	(e)$125,000	48	$8,250
1898..	118	2,550	246,845	515,495	2,915	3,935	(d)	.....	26,041	16,745,140	20	$1,260	(d)	100,000	87	19,565
1899..	(d)	.....	266,578	567,610	(d)	.....	(d)	.....	26,578	17,090,000	(d)	.....	(d)	.....	158	36,000
1900..	(d)	.....	215,052	507,995	(d)	.....	(d)	.....	25,231	16,148,440	(d)	.....	(d)	175,000	71	25,105
1901..	(d)	.....	212,678	755,955	152	185	(d)	.....	24,558	15,513,765	(d)	.....	(d)	235,000	78	20,905

MINERAL IMPORTS OF VICTORIA. (c)

Year.	Coal.		Iron and Steel.
1897..	880,812	$1,143,285	56,852	$2,294,645
1898..	871,896	1,288,440	.....	2,074,705
1899..	841,199	1,380,685	.....	3,507,105
1900..	701,616	2,018,615	.....	3,702,985
1901..	722,208	2,280,200	.....	3,570,060

MINERAL EXPORTS OF VICTORIA. (c)

Year.	Coal.		Coke and Charcoal.		Gold. Bullion.	Gold. Specie.	Silver. (Specie)
1897..	283	$1,980	1,212	$15,690	$969,055	$31,392,535	$11,605
1898..	411	1,775	567	7,033	1,355,240	28,258,635	122,300
1899..	445	1,695	430	8,310	968,210	20,821,110	144,500
1900..	73,929	186,585	279	2,760	433,000	20,227,305	114,875
1901..	11,814	43,285	805	6,560	481,485	21,011,605	30,500

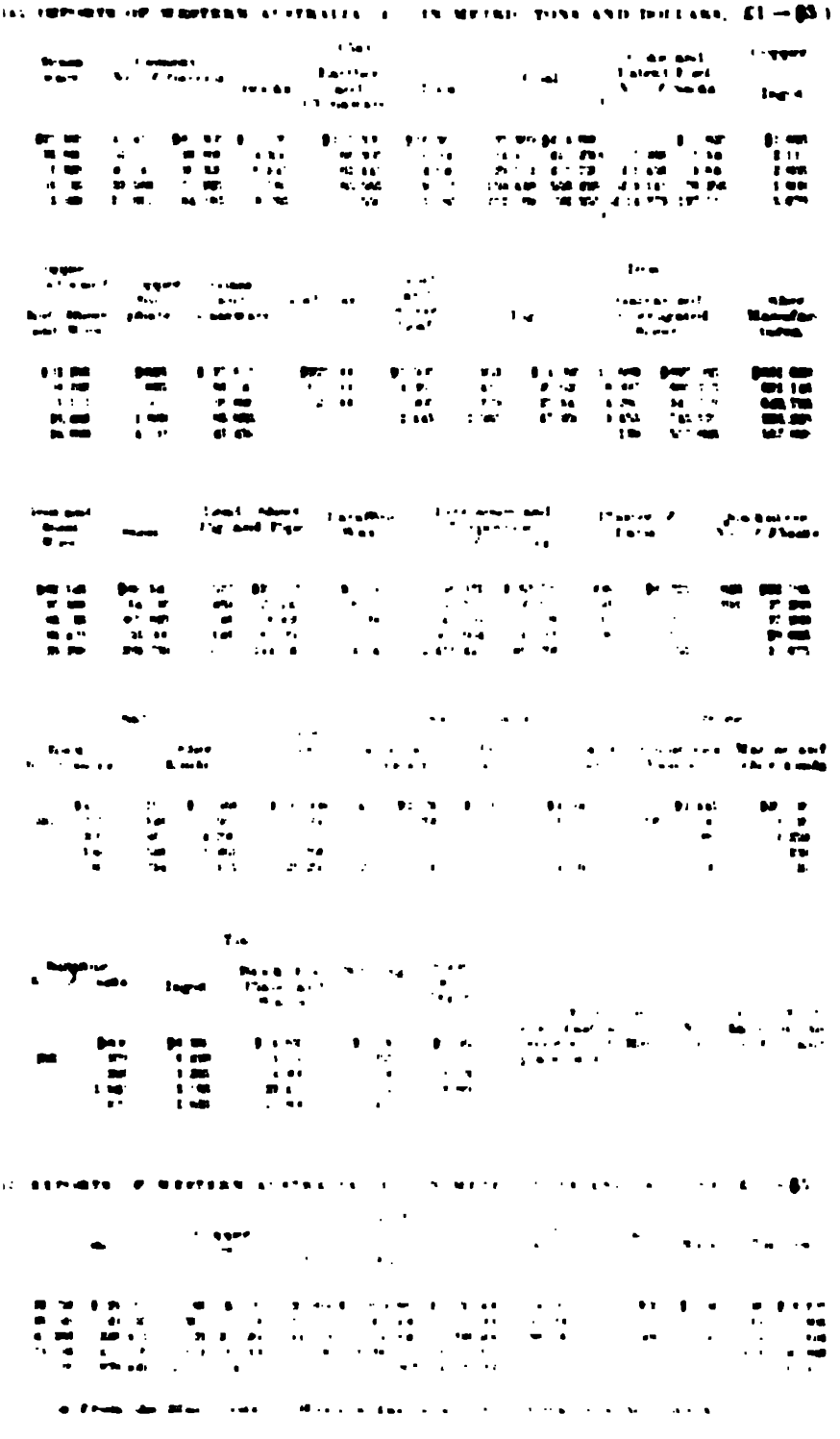
(a) From *Annual Reports of the Secretary for Mines of the Colony*; additional products in 1897: Bricks, estimated value, $11,250; pottery, estimated value, $8,000; in 1898: Brick, $12,500; pottery, $10,000; infusorial earth, 142 tons, $1,400; in 1899: Infusorial earth, $1,250; brick, $15,000; pottery, $12,500; building brick, $100,000; in 1901; infusorial earth, 805 metric tons, $7,500. (b) The values are not separately stated in the report, and are estimated at $20 per oz.=$643·02 per kg. (c) From *British Statistical Abstracts*. (d) Not stated in the reports. (e) Represents estimated value of building stones, basalt, sandstone, granite, slate, flagging, etc.

MINERAL PRODUCTION OF WESTERN AUSTRALIA. (a) (IN METRIC TONS AND DOLLARS; £1=$5.)

Year.	Coal.		Copper Ore.		Gold.—Kg.		Iron Ore.	
1898.....	330	$20,500	6,363	.....	28,986	$19,792,525	.....	.....
1899.....	55,308	129,755	3,012	$179,690	44,541	30,414,495	13,058	$44,695
1900.....	120,305	274,175	6,289	218,365	42,134	28,764,425	12,448	46,220
1901.....	110,721	342,805	10,319	376 230	51,914	35,448,840	20,898	66,230
1902.....	143,138	430,940	2,298	40,450	56,596	38,639,650	4,877	10,240

Year.	Lead Ore.		Limestone.		Precious Stones.		Silver.—Kg.		Tin Ore.	
1898.....	15	.....	.....	.....	.....	.....	.....	.....	84	$1,165
1899.....	84	$4,560	17,875	$14,190	.....	.....	.....	.....	340	126,350
1900.....	272	2,665	16,183	17,970	(b)	$130	894	$17,970	836	283,510
1901.....	(c)21	700	18,501	21,740	(b)	5,000	1,893	38,045	746	200,000
1902.....	(c)96	1,385	5,161	6,700	(b)	130	.....	.....	630	198,915

(a) From the *Report of the Department of Mines of Western Australia*, and the Blue Books for Western Australia. (b) Weight not stated. (c) Silver-lead ore.



AUSTRIA-HUNGARY.

THE latest official statistics of the mineral production, imports, and exports of Austria-Hungary are summarized in the following tables:

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND DOLLARS; 5 CROWNS—$1.)

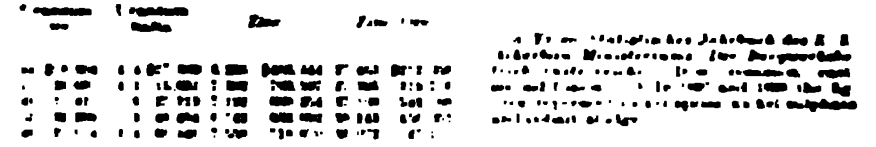
Year.	Alum.		Alum and Pyritous Shale.		Antimony.		Antimony Ore.		Asphaltic Rock.		Bismuth Ore.		Coal.	
1897.....	851	$22,164	21,585	$7,178	425	$45,292	864	$29,379	300	$3,547	1	.....	10,492,771	$15,361,946
1898.....	1,037	29,126	28,914	8,547	343	46,694	679	22,867	643	6,242	*Nil.*	.....	10,347,522	21,895,044
1899.....	604	16,713	19,879	6,711	271	33,692	410	15,344	2,635	15,134	0·3	$280	11,455,139	22,910,277
1900.....	620	18,426	3,004	3,608	153	14,844	201	7,065	887	9,608	4·0	2,558	10,902,545	19,118,184
1901.....	442	12,906	2,551	3,916	114	10,433	126	7,557	541	7,742	16·0	4,000	11,738,840	21,931,321

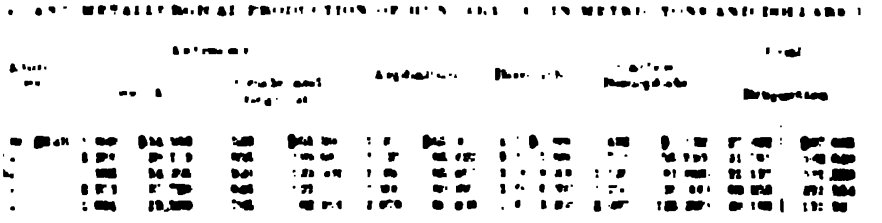
Year.	Coal, Lignite.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.		Gold—Kg.		Gold Ore.	
1897.....	20,458,098	$16,033,769	1,083	$245,874	125	$1,254	7,405	$111,757	276	$28,204	67·6	$37,470	647	$13,175
1898.....	21,063,361	17,397,116	1,041	251,124	360	4,526	6,791	101,399	209	18,864	71·5	40,800	448	21,950
1899.....	21,751,794	19,033,494	1,123	368,417	475	3,907	6,731	96,601	235	20,295	75·7	37,746	387	12,408
1900.....	21,539,917	22,526,715	881	307,693	474	4,401	5,825	95,699	234	25,299	70·9	34,107	227	8,566
1901.....	22,473,510	25,037,512	776	254,847	472	4,438	7,406	119,241	256	26,727	46·6	20,007	143	6,363

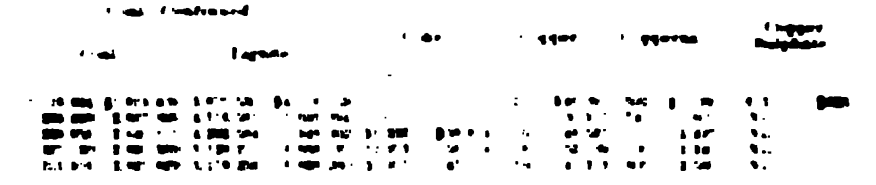
Year.	Graphite.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.		Litharge.	
1897.....	38,504	$541,058	1,613,876	$1,506,419	762,685	$10,650,493	9,680	$630,484	14,145	$464,760	1,696	$106,958
1898.....	33,062	349,426	1,733,649	1,691,075	837,767	11,805,345	10,340	715,805	14,368	492,156	1,580	112,286
1899.....	31,819	395,280	1,725,143	1,968,261	872,352	13,342,588	9,736	748,978	12,890	509,782	1,526	117,132
1900.....	33,663	418,126	1,894,458	2,218,599	879,132	14,194,844	10,650	944,431	14,314	607,887	1,388	116,057
1901.....	29,992	363,702	1,963,246	2,310,428	884,844	13,374,003	10,161	727,085	16,668	548,810	1,317	109,098

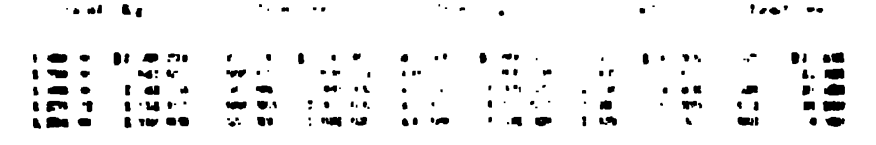
Year.	Manganese Ore.		Mineral Paint.		Nickel and Cobalt Products.(*b*)		Petroleum.		Quicksilver		Quicksilver Ore		Salt.	
1897.....	6,012	$19,184	3,653	$33,620	37·6	$10,022	275,204	$2,350,677	532	$476,048	88,286	$335,624	331,084	$10,294,578
1898.....	6,132	19,118	3,213	29,757	58·8	10,809	323,142	3,284,776	491	459,415	85,519	320,430	341,959	10,607,729
1899.....	5,411	18,239	2,055	24,567	38·1	8,572	309,590	3,185,541	536	492,021	92,323	354,946	342,059	10,194,789
1900.....	8,804	27,890	2,828	31,547	31·2	6,834	347,213	4,232,715	510	499,053	94,727	371,723	330,277	9,957,173
1901.....	7,796	25,466	1,701	26,743	20·5	2,998	404,662	4,602,118	595	547,513	97,260	392,705	333,338	9,988,231

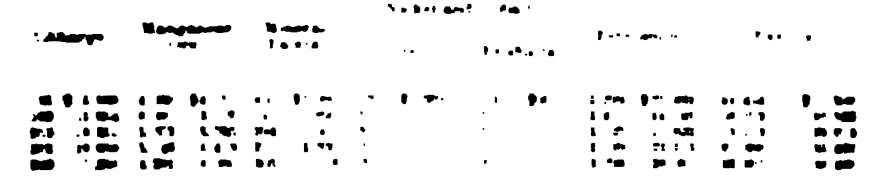
Year.	Silver—Kg.		Silver Ore.		Sulphuric Acid.		Sulphur, Crude Rock		Tin.		Tin Ore.		Tungsten Ore.	
1897.....	40,026	$780,965	20,628	$748,720	8,515	$90,422	530	$1,985	48	$16,806	16	$969	31	$7,669
1898.....	40,304	754,022	20,886	705,038	7,008	63,769	496	1,661	48	18,829	13	758	36	13,333
1899.....	39,564	761,978	21,554	742,922	7,814	63,045	555	1,526	41	24,639	54	551	50	22,259
1900.....	39,573	781,519	21,641	759,299	7,067	46,970	862	2,256	40	27,651	51	1,266	50	14,010
1901.....	40,205	781,045	21,363	731,487	7,073	45,453	4,911	12,107	49	30,364	42	1,505	45	10,749

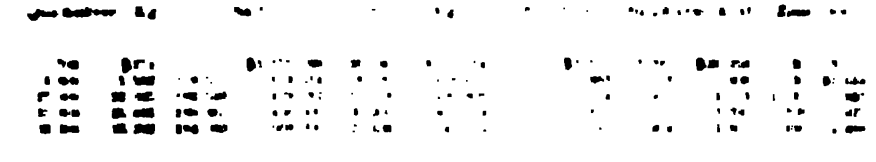












MINERAL IMPORTS OF AUSTRIA-HUNGARY. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Aluminum and Alloys.		Aluminum Sulphate and Chloride.		Ammoniacal Liquor.		Ammonium. Chloride and Sulphate.		Ammonium. Hydrate.		Antimony. Ore.		Antimony. Regulus. Kg.	
1897.....	346	$12,463	67	$50,006	1,351	$27,039	565	$2,710	339	$42,430	128	$6,677	8	$672	600	$78
1898.....	334	12,018	101	62,143	1,822	29,146	220	1,105	430	42,288	80	4,150	12	1,033	28,200	4,004
1899.....	332	11,938	120	58,015	1,299	20,789	72	363	358	37,957	46	2,587	10	840	30,400	5,167
1900.....	430	15,476	154	68,420	1,435	22,954	176	879	574	64,265	65	3,488	46	3,832	23,000	3,450
1901.....	413	14,800	152	87,000	1,882	37,600	298	1,400	620	64,000	44	2,800	27	2,200	1,500	250

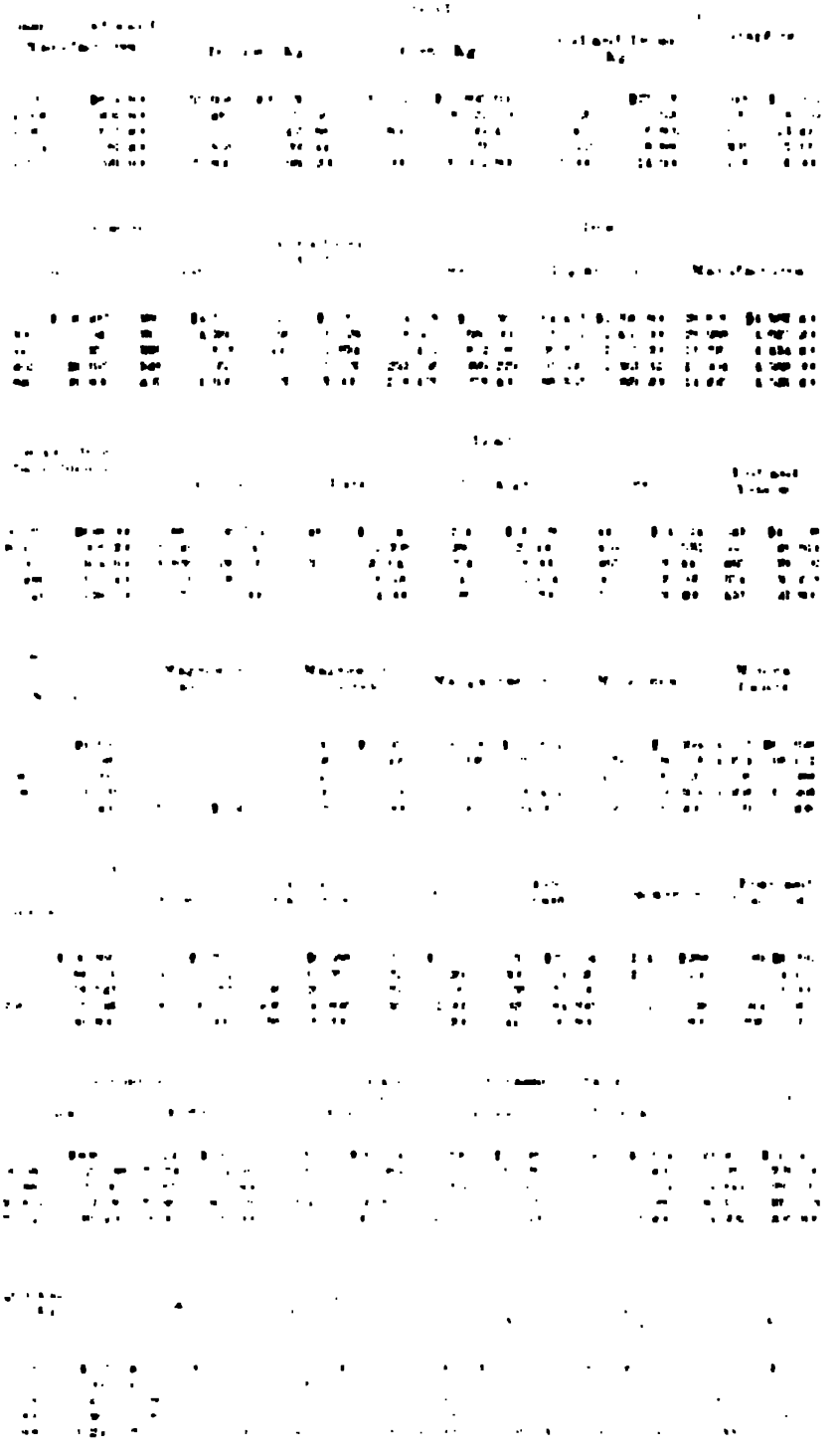
Year.	Arsenic, Arsenious Acid, and Sulphide.		Asbestos. Crude.		Asbestos. Manufactures.		Asphalt. Crude Rock.		Asphalt. Mastic and Bitumen.		Barytes (Including M'f'd Product).	
1897.....	259	$24,021	625	$33,041	134	$48,774	5,894	$28,894	1,309	$28,805	4,947	$23,128
1898.....	287	34,060	609	33,316	135	54,200	5,973	40,621	1,117	24,574	5,012	22,776
1899.....	294	32,290	865	44,698	135	55,146	7,301	62,471	1,546	28,594	5,443	45,000
1900.....	319	39,197	1,085	94,384	134	33,398	8,301	77,416	1,564	32,762	5,945	73,501
1901.....	351	38,600	1,678	149,600	103	26,600	5,702	53,400	1,106	22,200	6,335	77,400

Year.	Borax. Crude, and Boric Acid.		Borax. Refined.		Brass, German Silver and Tombac. Crude, Old, and Remnants.		Brass, German Silver and Tombac. Bars, Sheets, Wire, etc.		Brass, German Silver and Tombac. Wares.		Cement.	
1897.....	1,206	$68,772	63	$5,135	2,660	$489,052	152	$50,639	549	$658,920	32,479	$208,736
1898.....	784	44,871	185	14,832	3,242	650,147	182	51,577	607	765,324	30,745	197,479
1899.....	2,212	125,507	139	10,432	2,699	651,771	168	61,012	588	764,010	21,410	129,694
1900.....	3,056	172,996	98	7,778	2,654	658,681	54	22,111	579	752,960	25,747	154,409
1901.....	1,686	91,000	233	16,200	3,771	871,000	104	39,408	577	749,800	23,569	141,400

Year.	Chloride of Lime.		Chrome Ore.		Clay Products. Kaolin and Feldspar.		Clay Products. Manufactures.		Clay Products. Potters' and Other Clays.		Coal.	
1897.....	1,890	$58,256	1,109	$22,188	6,913	$75,376	186,297	$1,233,200	28,925	$104 655	5,121,475	$10,552,857
1898.....	2,851	85,542	2,206	39,701	7,991	88,180	183,822	1,230,400	31,905	114,859	5,396,760	12,534,217
1899.....	3,749	113,045	1,874	35,990	8,153	94,016	177,119	1,110,000	30,799	110,876	5,296,700	14,072,860
1900.....	3,326	106,422	2,823	59,287	6,847	80,981	179,748	1,116,400	30,418	91,256	6,342,989	19,068,989
1901.....	2,396	65,200	860	18,000	7,687	84,600	190,663	1,119,400	36,448	131,200	5,827,332	18,084,800

Year.	Coal, Lignite.		Coke.		Copper. Ore.		Copper. Crude and Old.		Copper. Bars, Sheets, Wire, etc.		Copper Sulphate.	
1897.....	19,609	$43,088	533,463	$2,279,648	81	$4,586	15,926	$2,981,060	94	$30,981	6,892	$577,900
1898.....	19,393	42,446	606,783	2,876,321	64	1,272	17,443	4,706,135	159	55,142	5,271	453,306
1899.....	20,879	46,850	564,005	2,662,153	*Nil.*	.....	16,185	5,969,925	156	71,043	2,345	274,362
1900.....	67,740	163,172	690,776	3,204,670	16	1,310	18,970	7,108,485	130	54,902	3,516	404,551
1901.....	22,253	58,800	612,909	3,449,800	112	4,600	17,504	6,305,600	88	35,600	2,822	294,400

Year.	Copper and Iron Sulphates, Mixed.		Copperas.		Cryolite.		Fertilizers, Mineral		Fluorspar.		Glass. Crude and Ground.		Glass. Remnants.	
1897.....	153	$5,512	401	$2,408	211	$44,194	7,583	$91,001	4,201	$41,344	270	$43,152	4,651	$32,558
1898.....	93	3,352	466	2,330	275	58,676	8,482	101,784	4,169	41,809	299	47,840	6,860	48,021
1899.....	28	994	408	1,920	342	73,822	8,120	64,964	4,958	41,947	341	54,600	8,574	60,017
1900.....	45	1,602	343	1,715	342	68,550	5,757	46,200	5,649	48,615	360	57,632	6,618	46,400
1901.....	.....	.....	293	1,200	428	75,600	6,772	54,200	6,575	68,900	375	60,000	6,564	45,900



Year.	Slag and Slag Wool.		Slate, Roofing and Other.		Sodium Salts. Bi-Sulphate.		Carbonate.		Carbonate. (Calcined.)		Hydrate.	
1897.....	4,717	$8,868	16,758	$406,080	91	$1,826	45	$1,088	2,787	$66,893	1,450	$49,518
1898.....	9,655	19,319	16,025	399,200	89	1,784	53	642	2,408	46,451	1,498	51,892
1899.....	5,665	11,330	15,562	379,550	85	1,692	62	748	1,123	23,591	1,669	57,521
1900.....	4,679	9,358	13,047	319,646	73	1,464	104	1,252	1,141	28,528	1,836	62,000
1901.....	3,068	6,200	11,555	284,200	98	2,000	77	1,000	911	21,800	1,293	54,000

Year.	Sodium Salts.—*Continued.* Nitrate.		Sulphate.		Stone. Lithographic Stone.		Marble.		Paving.		Not Elsewhere Specified.	
1897.....	39,600	$1,584,016	2,879	$20,158	524	$20,739	2,333	$27,995	16,961	$67,843	118,848	$308,980
1898.....	41,773	1,670,928	4,476	31,186	786	31,146	2,769	33,224	11,234	44,936	99,198	344,505
1899.....	47,301	1,892,060	5,394	35,060	610	24,176	2,850	39,901	27,067	108,270	82,878	304,332
1900.....	54,559	2,182,376	5,110	30,659	640	25,336	3,133	43,860	5,780	28,123	81,347	264,397
1901.....	68,283	2,658,000	4,452	26,800	616	24,200	2,908	51,000	11,299	45,200	77,695	236,400

Year.	Sulphur.		Sulphuric Acid.		Tin. Ingot, Crude, Old, etc.			Salts.	Whetstones.		Zinc. Metal.	
1897.....	21,406	$359,942	5,877	$58,967	3,467	$1,060,933	22·3	$4,995	4,151	$107,929	16,599	$1,394,299
1898.....	20,655	358,316	9,724	97,389	3,769	1,313,016	20·9	5,518	3,490	90,750	17,471	1,712,158
1899.....	23,504	387,938	10,245	102,692	3,004	1,742,610	30·2	10,570	3,717	96,645	15,225	1,897,853
1900.....	27,795	444,228	10,643	106,717	3,439	2,214,652	23·9	9,092	3,643	94,721	17,843	1,980,090
1901.....	25,300	379,200	11,712	117,400	3,671	2,144,000	24·9	6,800	3,445	75,800	16,921	1,421,400

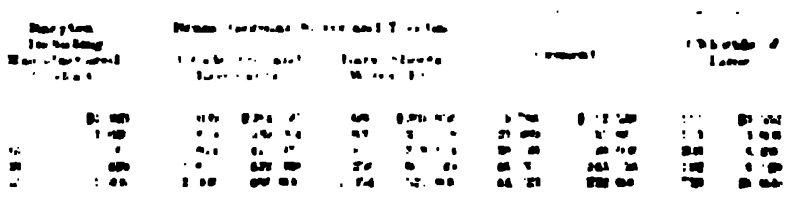
Year	Zinc.—*Continued.* Bars, Sheets, Wire, etc.		Calamine and Other Ores.		White.		Metal Wares Other than Iron and Precious Metals.		Ore and Minerals Unspecified.	
1897.....	356	$37,214	7,863	$113,222	(*b*) 577	$55,790	2,056	$1,613,600	155,741	$1,731,515
1898.....	458	52,461	14,112	259,659	(*b*) 697	59,783	2,121	1,754,800	158,997	1,674,305
1899.....	481	70,996	12,730	254,596	(*b*) 750	74,580	2,292	1,971,600	174,249	1,881,780
1900.....	667	98,651	14,181	340,332	(*b*) 875	83,971	2,091	1,755,800	181,052	1,986,710
1901.....	579	74,200	18,408	331,200	423	39,000	2,089	1,720,000	183,089	1,692,200

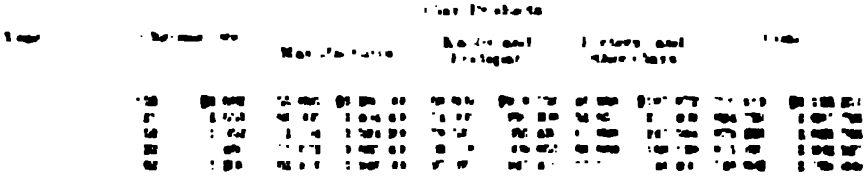
(*a*) From *Statistik des Auswärtigen Handels Oesterreichisch Ungarischen Zollgebiets.* (*b*) Includes zinc sulphide. (*c*) Not reported separately.

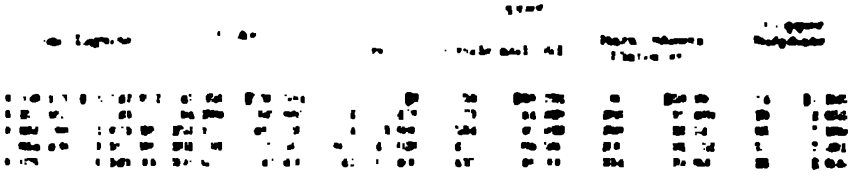
MINERAL EXPORTS OF AUSTRIA-HUNGARY. (*a*) (IN METRIC TONS AND DOLLARS.)

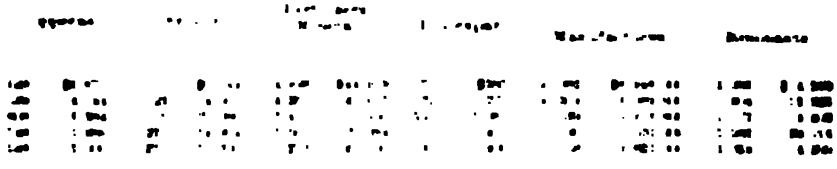
Year.	Alum.		Aluminum, Sulphate and Chloride.		Ammonium. Chloride and Sulphate.		Hydrate.		Ammoniacal Liquor.	
1897.....	70	$2,307	210	$4,634	4,188	$193,295	39	$2,880	592	$3,553
1898.....	83	2,729	253	5,557	4,886	220,084	23	1,627	724	4,344
1899.....	54	1,822	233	5,319	7,576	361,887	41	3,046	734	4,406
1900.....	44	1,506	164	3,434	7,004	371,798	82	5,761	942	5,654
1901.....	55	1,800	211	5,000	8,868	468,600	113	8,400	705	4,200

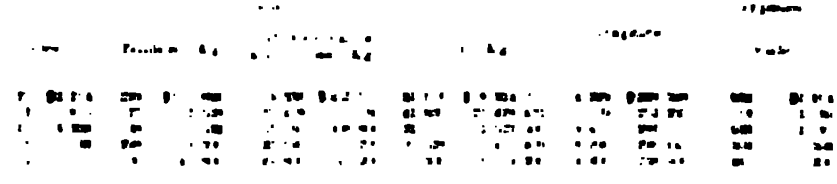
Year.	Antimony. Ore.		Regulus.		Arsenic, Arsenious Acid, and Orpiment.		Asbestos. Crude.		Manufactured.		Asphalt. Rock and Earth.		Mastic and Bitumen	
1897.....	289	$25,467	359	$45,209	16	$1,029	56	$1,644	19	$12,000	102	$773	2,593	$25,930
1898.....	266	23,417	679	89,694	29	3,276	150	3,567	28	22,149	183	1,413	2,126	21,264
1899.....	562	49,447	240	38,384	47	6,729	71	2,136	60	33,202	1,143	9,984	2,619	41,800
1900.....	247	21,727	276	39,758	65	6,883	47	2,570	167	56,490	1,218	8,589	2,177	34,965
1901.....	179	13,600	385	49,200	80	9,800	36	2,800	165	55,200	298	2,800	1,909	30,600

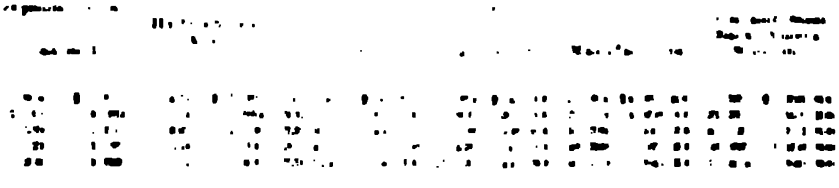


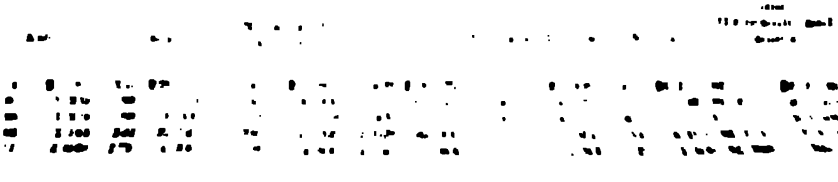












Year.	Magnesite Calcined.		Manganese Ore.		Millstones.		Mineral Paints.		Nickel, Bars, Sheets, Wires, Etc.		Nickel and Cobalt Ores	
1897.....	(b)	.....	622	$8,214	1,773	$106,386	1,621	$24,308	170	$145,184	117	$11,0[illegible]
1898.....	(b)	.....	1,961	23,531	2,109	126,546	2,153	32,580	76	66,316	121	4,[illegible]
1899.....	(b)	.....	1,127	14,426	1,904	106,613	2,061	31,543	38	35,903	75	6,[illegible]
1900.....	(b)	.....	463	6,014	1,871	97,261	1,905	25,440	115	102,720	114	9,[illegible]
1901.....	40,226	$321,800	398	5,000	1,971	102,400	1,947	31,200	89	73,800	120	10,[illegible]

Year.	Nitric Acid.		Oxide. (Potash.)		Ozokerite.		Peat and Peat Coke.		Petroleum.			
									Crude.		Refined.	
1897.....	310	$20,902	5,997	$381,395	5,153	$762,570	1,655	$4,632	1,600	$15,364	13,082	$213,700
1898.....	294	19,384	7,252	465,479	4,462	696,088	3,400	9,929	1,076	10,330	3,662	46,858
1899.....	420	27,313	10,113	760,568	5,441	859,600	4,010	11,710	1,823	21,872	7,778	147,704
1900.....	519	33,521	7,792	641,258	5,162	1,032,320	5,607	16,822	2,313	35,622	21,070	446,334
1901.....	632	39,200	4,234	305,600	2,717	554,400	4,558	14,600	2,100	29,400	9,448	208,600

Year.	Potassium Salt Chloride.		Pyrites.		Quicksilver.		Salt.		Silica. (Quartz and Quartz Sand.)		Silver.	
											Bullion—Kg.	
1897.....	1,005	$36,166	255	$1,379	529	$408,697	182	$1,091	31,347	$94,727	4,120	$66,250
1898.....	994	35,798	3,039	16,413	468	378,548	240	1,439	39,033	117,806	4,870	78,310
1899.....	974	35,078	5,201	29,123	490	456,680	117	735	68,412	210,142	48,240	849,094
1900.....	879	31,638	17,162	102,969	492	517,020	1,915	11,490	69,434	212,744	54,000	961,200
1901.....	909	31,000	16,491	99,000	540	546,800	3,616	21,600	29,580	97,000	21,900	228,400

Year.	Silver.—*Continued.*						Slag and Slag Wool.		Slate, Roofing and Other.	
	Coin—Kg.		Old and Dross. Kg.		Ore.					
1897.....	114,560	$1,681,500	116,700	$68,648	(b)	.....	65,966	$131,931	4,581	$102,461
1898.....	26,130	378,376	121,400	71,290	1	$56	75,018	180,043	4,972	110,862
1899.....	15,240	221,732	84,800	180,490	12	408	109,180	393,048	5,535	124,080
1900.....	17,441	271,729	97,800	25,000	69	4,397	125,113	450,405	5,205	116,551
1901.....	43,100	597,800	104,500	23,400	0·3	.....	108,944	374,200	4,001	99,600

Year.	Sodium.										Stone.	
	Carbonate.		Carbonate, Calcined.		Nitrate, Crude.		Salts, Potassium Nitrates, Refined.		Sulphate. (c)		Lithographic.	
1897.....	599	$7,782	3,372	$86,074	61	$2,562	120	$9,728	6,910	$55,281	22	$1,115
1898.....	952	13,140	2,895	60,384	33	1,344	180	2,931	7,248	58,208	8	405
1899.....	1,894	25,877	1,502	31,534	88	3,593	188	12,565	5,716	45,853	11	565
1900.....	2,226	32,057	548	14,250	35	1,505	117	7,839	7,390	58,809	7	351
1901.....	1,737	26,600	452	10,000	25	1,200	126	8,000	7,960	57,600	2	200

Year.	Stone.—*Continued.*								Sulphur.		Sulphuric Acid.	
	Limestone.		Marble.		Paving.		Not Elsewhere Specified.					
1897.....	11,373	$22,747	2,994	$35,932	38,256	$221,886	223 321	$528,538	947	$18,950	7,908	$94,153
1898.....	25,117	50,233	2,954	35,452	54,953	318,727	252,229	624,070	923	18,464	9,880	97,911
1899.....	11,052	22,105	4,096	65,542	67,212	389,828	239,819	576,265	885	17,694	12,422	144,730
1900.....	13,878	30,818	3,811	60,981	58,121	232,481	197,932	452,164	1,285	25,694	12,693	149,796
1901.....	23,909	31,000	4,394	70,200	51,618	206,400	200,461	378,600	1,225	24,600	10,373	121,800

Year.	Tin.						Whetstones.		Zinc.			
	Ingot and Old.		Bars, Plates, Sheets, etc.		Ash.				Ash.		Metal.	
1897.....	87	$20,880	75	$25,534	306	$66,009	2,323	$73,748	197	$14,198	770	$48,182
1898.....	96	21,628	78	26,353	324	81,598	2,316	68,730	298	16,677	1,184	87,231
1899.....	167	77,339	77	40,380	273	95,410	2,215	75,303	73	4,659	1,614	54,973
1900.....	153	79,352	112	73,590	208	85,444	2,270	77,180	149	9,516	1,068	187,082
1901.....	162	72,400	109	65,400	257	102,800	2,196	74,800	165	16,800	1,374	77,000

BELGIUM.

THE most important articles of mineral production in Belgium are coal, iron, lead, zinc, manganese ore and phosphate of lime. Developments in these industries are described specifically under the respective captions elsewhere in this volume. The official statistics of production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f.=$1.)

Year.	Iron Ore.		Lead Ore.		Manganese Ore.		Pyrites.		Zinc Ore.				Totals.
									Blende.		Calamine.		
1897.....	240,774	$252,902	108	$3,230	28,372	$68,540	1,828	$3,990	6,804	$74,340	4,150	$41,270	$444,272
1898.....	217,870	211,644	138	4,301	16,440	42,300	147	177	7,350	98,262	4,125	51,250	407,934
1899.....	201,445	214,620	137	6,540	12,120	31,160	288	360	5,736	90,160	3,730	40,920	423,760
1900.....	247,890	264,020	230	12,656	10,820	26,070	400	228	5,715	67,886	3,000	43,430	414,340
1901.....	218,780	222,580	220	8,413	8,510	22,160	560	392	4,445	38,535	2,200	16,130	308,210

PRODUCTION OF MINERAL FUEL IN BELGIUM.

Year.	Coal.							Coke.		
	Quantity. Metric Tons.	Value.		Profit.		Number of Workmen.	Average Annual Wages.	Ovens. Active.	Number of Workmen.	Consumption of Coal. Metric Tons
		Total.	Per Ton	Total.	Per Ton					
1897	21,492,446	$44,134,420	$2·05	3,911,330	$·182	120,382	$205	3,645	2,566	2,968,620
1898.....	22,088,335	48,578,780	2·20	4,654,921	·210	122,846	219	4,028	2,519	2,944,096
1899.....	22,072,068	54,898,780	2·49	7,568,600	·343	125,258	234	(*d*)	2,894	(*d*)
1900.....	23,462,817	81,698,960	3·48	12,453,600	·531	132,749	283	(*d*)	2,928	(*d*)
1901.....	22,213,410	67,654,818	3·05	10,362,146	·466	134,092	249	4,967	2,821	2,486,330

Year.	Coke—*Continued.*			Briquettes from Coal.					
	Quantity. Metric Tons.	Value.		Number of Works, Active.	Number of Workmen.	Consumption of Coal. Metric Tons.	Quantity. Metric Tons.	Value.	
		Total.	Per Ton					Total.	Per Ton
1897.....	2,207,840	$7,572,891	$3·43	37	(*b*)	1,129,791	1,945,114	$3,112,785	$2·50
1898.....	2,161,162	8,104,357	3·75	37	1,191	1,227,730	1,951,884	3,933,049	2·04
1899.....	2,304,607	9,448,889	4·10	(*d*)	1,234	(*d*)	1,976,050	4,096,120	3·21
1900.....	2,434,678	13,098,567	5·38	40	1,263	(d)	1,395,910	6,574,736	4·71
1901.....	1,847,790	8,222,621	4·45	(d)	1,486	1,449,980	1,381,960	6,196,350	3·86

Year. (h)	Lime.	M'f'es of Metals Not Iron and Steel.	Mica. Crude and Cut.		Mica. Ground.	Mineral Oils. Gallons.		Nickel in Ore, Matte, etc.		Ores. Gold Quartz, etc.	Ores. Iron.		Ores. Lead. (e)	
	$	$		$			$		$	$		$		$
1898	48,307	53,317	231	69,513	(i)	9,530	2,061	6,696	970,531	3,587,953	236	402	19,939	1,008,147
1899	64,112	34,532	538	148,239	(i)	4,268	1,194	6,545	994,537	3,272,702	1,677	4,968	15,443	895,349
1900	77,395	68,610	487	136,332	20	17,934	2,660	6,120	1,040,498	14,148,543	3,925	7,689	8,995	678,859
1901	83,439	126,357	406	146,848	$2,740	19,942	2,008	4,327	958,365	24,445,156	58,401	150,657	29,747	2,512,061
1902	111,910	361,428	453	942,290	20	2,748	331	1,762	834,513	19,668,015	477,078	1,308,901	13,886	889,310
							t							

Year. (h)	Ores.—Continued. Manganese.		Ores.—Continued. Silver. (d)		Phosphate of Lime.		Pyrites.		Salt. Bushels.		Sand and Gravel.		Stone and Marble.	Tin M'f's
		$		$		$		$		$		$	$	$
1898	7	1,371	211	3,519,786	232	1,090	18,752	221,564	5,559	1,139	150,270	80,952	61,030	5,578
1899	24	882	137	2,620,381	781	9,290	11,707	27,377	5,209	1,518	162,509	98,492	66,516	3,159
1900	57	2,521	71	1,354,053	135	2,285	13,507	32,499	15,151	3,458	227,942	102,151	240,104	3,472
1901	36	1,945	152	2,420,750	6	120	22,146	54,357	56,461	11,288	197,065	108,509	128,039	14,481
1902	500	6,112	139	2,055,428	64	1,880	24,088	57,623	21,778	4,965	153,982	119,421	137,160	26,594

(a) From the tables of the *Trade and Navigation of the Dominion of Canada*. The imports figures are for home consumption only. The exports are those of domestic produce. (b) Including coal dust. (c) Represents fine copper contained in ore, matte, regulus, etc. (d) Silver contents of ores. (e) Represents lead contained in ore. (f) Includes manufactures. (g) Of foreign production. (h) Fiscal years ending June 30. (i) Not reported.

MINERAL PRODUCTION OF BRITISH COLUMBIA. (a) (IN METRIC TONS.)

Year.	Coal.		Coke.		Copper.		Gold—Kg. Lode.		Gold—Kg. Placer.		Lead. (b)		Silver—Kg.	
						$		$		$		$		$
1898	1,154,039	3,407,595	35,560	175,000	3,298	874,781	3,423	2,201,217	1,600	643,346	14,376	1,077,581	133,200	2,375,841
1899	1,314,838	3,883,396	34,709	171,255	3,503	1,251,453	4,302	2,857,573	2,092	1,344,900	9,917	878,870	91,425	1,663,708
1900	1,462,629	4,318,785	86,511	425,745	4,535	1,615,249	5,199	3,453,381	1,999	1,278,724	28,739	2,691,897	123,112	2,309,200
1901	1,483,696	4,380,993	129,120	635,405	12,521	4,446,963	6,543	4,348,603	1,509	970,100	23,398	2,002,733	160,223	2,884,745
1902	1,419,752	4,192,182	130,133	640,075	13,434	3,446,673	7,356	4,888,269	1,669	1,073,140	10,222	824,832	70,095	1,941,328

(a) From the *Annual Reports of the Minister of Mines*. (b) Attention should be called to the discrepancy between certain of these figures and those of the Canadian Geological Survey; practically the total production of lead in the Dominion is from British Columbian ore.

MINERAL PRODUCTION OF NOVA SCOTIA. (a) (d) (IN METRIC TONS.)

Year. (c)	Barytes.	Coal.	Coke.	Gold. Kg.	Grindstones.	Gypsum. (b)	Iron. Ore.	Iron. Pig.	Manganese Ore.	Stone, Limestone.	Tripoli and Silica.
1898	.....	2,317,957	42,672	967	38,000	133,096	31,547	.....	76	24,384	.....
1899	308	2,683,373	56,372	864	50,000	142,240	16,428	.....	102	32,512	910
1900	721	3,290,057	62,992	945	56,500	124,237	15,755	.....	8	50,800	998
1901	544	3,683,373	121,920	919	286	137,852	380,629	81,678	10	97,359	813
1902	684	4,432,675	412,650	879	4,064	184,768	e444,281	187,057	152	227,184	.....

(a) From the *Annual Reports of the Department of Mines of Nova Scotia*. (b) Amount exported. (c) For the fiscal year ending September 30. (d) There was also produced in 1899, 400 net tons of copper ore; in 1900, 600 net tons copper ore; in 1902, 1,390 net tons of moulding sand. (e) Including 474,517 net tons of imported ore.

MINERAL PRODUCTION OF ONTARIO. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Arsenic.		Clay Products. Brick, Common. Number.		Clay Products. Brick, Paving and Terra Cotta. Number.		Pottery.	Tiles, Drain. Thousands.	
				$		$			$
1898	Nil	.....	170,000,000	914,000	7,754,868	87,894	$155,000	22,668	225,000
1899	52	$4,842	233,989,000	1,313,750	10,808,000	105,000	101,000	21,027	240,246
1900	275	22,725	240,430,000	1,379,590	14,271,600	141,369	157,449	19,544	209,738
1901	630	41,677	259,265,000	1,530,460	16,585,000	141,394	198 950	21,592	231,374
1902	....	48,000	.....	1,411,000	.....	186,171	171,315	.....	199,000

Year.	Phosphate of Lime. Cubic Meters.		Sand. Cubic Meters.		Slate. Pieces.	Slate. Cubic Meters.	Slate. Total Value.	Building Stone—Cubic Meters. Conglomerate.		Dolomite.		Flagstones. Square Meters.	
1897.	350,056	$496,762	559,141	$237,196	41,422,000	1,445	$335,780	220	$5,500	52,720	$13,908	107,572	$71,646
1898.	156,220	308,220	287,805	136,220	42,311,000	210	350,660	180	4,680	37,100	13,068	170,672	157,650
1899.	190,090	342,180	627,770	241,698	44,167,000	200	358,112	200	5,400	56,400	19,838	144,330	127,355
1900.	215,670	367,164	653,780	250,996	43,941,000	1,410	333,210	280	7,900	45,000	13,050	153,217	143,343
1901.	c222,520	361,398	636,090	240,068	39,090,000	.....	283,900	(b)	.....	31,500	11,808	105,470	120,494

Year.	Stone. Freestone. Cubic Meters.		Limestone. Cubic Meters.		Limestone for Flux. Cubic Meters.		Marble. Cubic Meters.		Paving Stones. *Pieces.*		Whetstones and Hones—*Pieces.*	
1897	181,746	$3,076,994	3,010,877	$2,730,730	225,300	$89,085	17,797	$471,954	95,542,700	$1,739,875	43,150	$16,740
1898	215,417	3,177,534	2,968,997	2,580,695	212,688	74,740	16,610	547,100	108,025,000	2,016,314	89,150	22,590
1899	199,294	3,249,146	3,238,875	2,735,025	195,506	77,956	17,740	601,170	114,106,900	2,236,411	82,100	14,160
1900	157,294	3,200,248	3,238,205	3,090,602	239,250	89,112	15,990	536,140	107,294,000	2,192,352	105,000	15,160
1901	167,310	2,834,304	3,751,880	3,124,892	198,370	63,280	15,390	513,910	110,980,000	2,273,980	160,150	20,150

(*a*) From *Statistique des Mines, Minières, Carrières, et Usines Métallurgiques*, by Emil Harsé, except the figures for 1901, which are from *Statistique des Industries Extractives et Métallurgiques*. Belgium also produced, in 1896, manganese pig-iron, 11,391 tons, $154,160; kaolin,130,960 cu. m., $218,560; in 1897, manganese pig-iron, 12,636 tons, $199,700; and in 1901, kaolin, 2,640 tons $5,080. (*b*) Not stated in the report. (*c*) Metric tons. (*d*) Statistics not yet available.

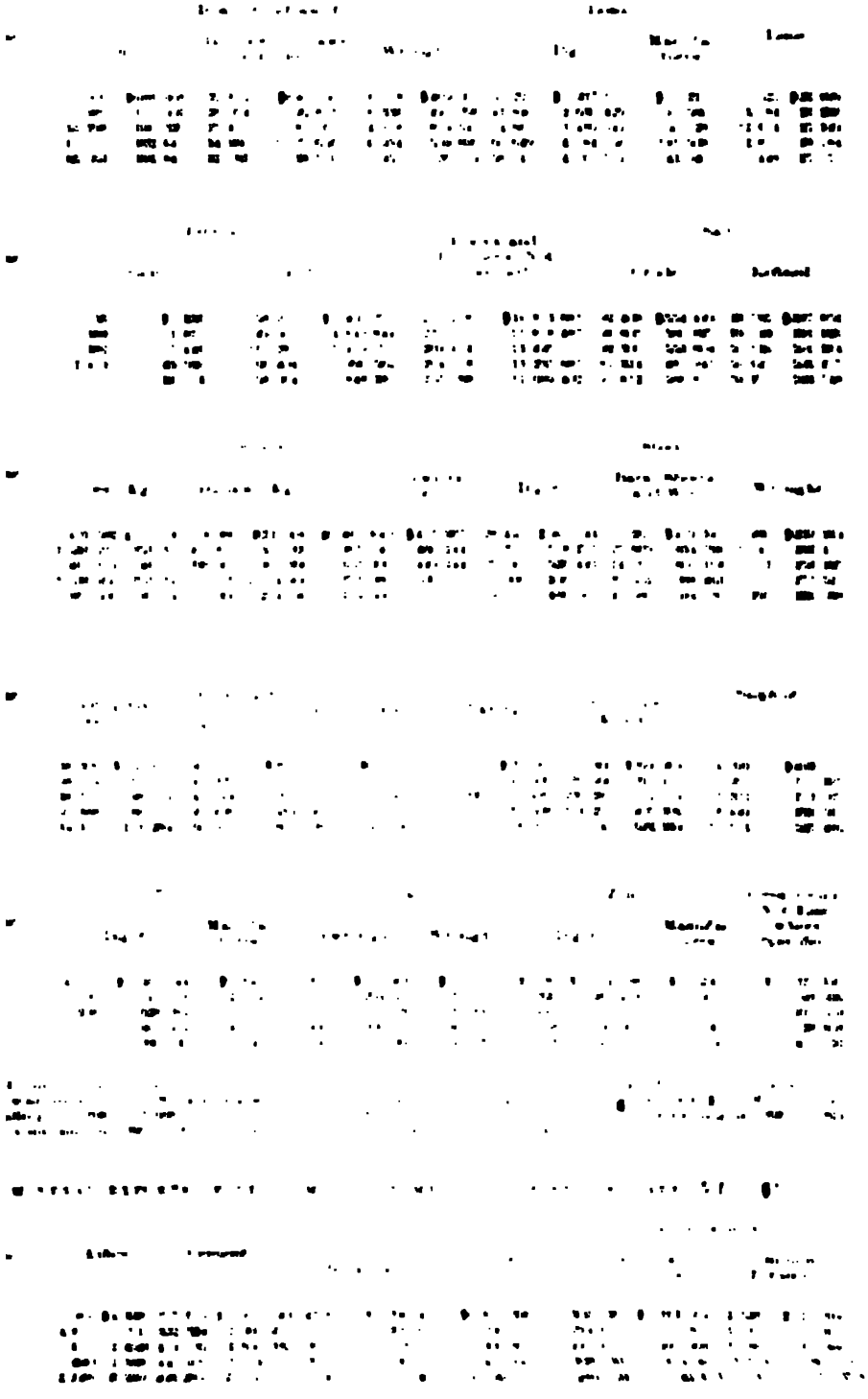
MINERAL IMPORTS OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Ashes.		Cement.		Chemical Products. Soda Salts.		Chemical Products. Not Specified.	Clay Products. (*b*) Terra Cotta.		Clay Products. (*b*) Common Pottery.	
1896.....	6,747	$96,988	30,565	$188,392	194,202	$11,969,011	$5,438,985	85,486	$629,221	2,065	$103,331
1897.....	10,870	43,491	17,681	118,160	181,676	7,419,315	6,048,423	80,493	549,631	2,115	105,756
1898.....	8,199	32,796	34,089	231,471	152,164	5,088,089	6,896,430	92,149	610,058	2,007	104,431
1899.....	15,818	63,271	18,649	128,675	249,756	7,996,717	6,451,947	99,156	633,955	2,856	102,098
1900.....	15,428	61,711	12,773	86,858	222,941	7,322,966	7,157,219	90,852	585,216	4,281	127,254

Year.	Clay Products—*Con* Earthenware.		Clay Products—*Con* Porcelain	Coal.		Coal Briquettes.		Coke.		Copper and Nickel. Crude.	
1896.....	c$272,894	d	d$177,307	1,693,376	$5,249,466	1,561	$5,151	260,273	976,094	15,506	$3,397,486
1897.....	c298,535	d	189,434	2,017,344	6,455,501	692	2,212	269,606	1,159,206	14,821	3,356,943
1898.....	179,866		345,067	2,202,517	7,208,306	1,750	6,585	180,590	784,590	14,947	5,089,574
1899.....	438,072		233,394	2,844,274	10,523,814	10,722	43,960	296,508	1,482,540	8,327	2,330,798
1900.....	430,685		263,241	3,288,510	13,976,167	21,813	121,062	289,673	1,767,005	13,768	5,507,109

Year.	Copper and Nickel.—*Con.* Hammered, Drawn or Rolled.		Copper and Nickel.—*Con.* Wrought.	Glass and Glassware. Common (Bottles, Broken Glass, etc.)	Glass and Glassware. All Other Kinds.	Gold (Including Platinum). Ore—Kg.		Gold (Including Platinum). Unwrought—Kg.	
1896.....	1,109	$331,718	$188,981	6,980	$213,380	$541,295	98	$614	4,988	$3,300,982
1897.....	1,418	405,576	193,242	4,699	143,130	664,176	.....	.....	3,894	2,683,971
1898.....	1,891	765,000	205,705	4,247	99,608	635,021	8,390	55,374	1,282	883,041
1899.....	2,174	999,995	236,863	3,757	90,473	651,208	51	337	1,126	768,477
1900.....	2,087	960,164	251,765	5,671	134,352	663,286	1,250	8,250	1,728	1,190,346

Year.	Gold.—*Continued.* Coin.	Gold.—*Continued.* Jewelry, etc.	Guano.		Iron and Steel Filings.		Iron. Ore.		Iron. Pig.	
1896.....	599,540	$757,507	25,946	$1,087,846	11·1	$ 98	2,069,678	$3,982,365	394,389	$3,697,09
1897.....	1,726,700	701,585	5,162	185,895	98·4	827	2,544,877	4,834,316	302,198	3,815,89
1898.....	372,000	840,598	10,657	393,964	18·0	158	2,359,353	4,379,950	317,889	3,792,15
1899.....	744,000	965,170	16,111	579,991	184·0	1,748	2,990,195	5,360,304	388,988	4,666,86
1900.....	459,430	921,624	15,892	599,964	8·0	80	2,999,615	5,370,198	359,954	4,320,87



Year	Clay Products.—Continued. Earthenware		Porcelain		Coal		Coal Briquettes		Coke	
1896	4,982	$513,250	190	$54,282	4,649,759	$14,414,377	458,974	$1,547,594	403,867	$3,226,501
1897	4,986	594,502	274	45,765	4,648,544	14,286,241	615,674	2,132,730	388,695	3,240,700
1898	10,591	640,025	218	35,372	4,570,955	15,113,951	606,285	2,020,950	470,635	3,955,114
1899	4,417	498,125	264	39,750	4,589,999	16,905,071	585,625	2,125,625	1,066,750	5,963,700
1900	5,010	625,671	261	37,245	5,230,591	22,259,212	604,954	3,356,985	1,073,313	6,547,310

Year.	Copper and Nickel. Crude.		Hammered, Drawn or Rolled.		Wrought.	Glass and Glassware. Common (Bottles, Broken Glass, etc.).		Plate.		All Other Kinds.	
1896	11,700	$2,714,477	2,073	$601,277	$169,594	3,647	$95,574	$3,468,668		178,611	$12,194,634
1897	9,994	2,324,659	1,995	570,761	198,685	3,546	93,495	3,761,219		174,232	11,448,659
1898	6,511	2,108,956	1,770	742,402	161,726	2,747	87,480	3,007,895		95,295	3,098,385
1899	4,665	1,966,099	2,111	970,492	261,060	2,850	89,283	4,942,206		196,842	12,553,516
1900	5,411	3,364,241	2,097	964,639	276,613	2,998	78,004	4,412,987		159,557	10,896,089

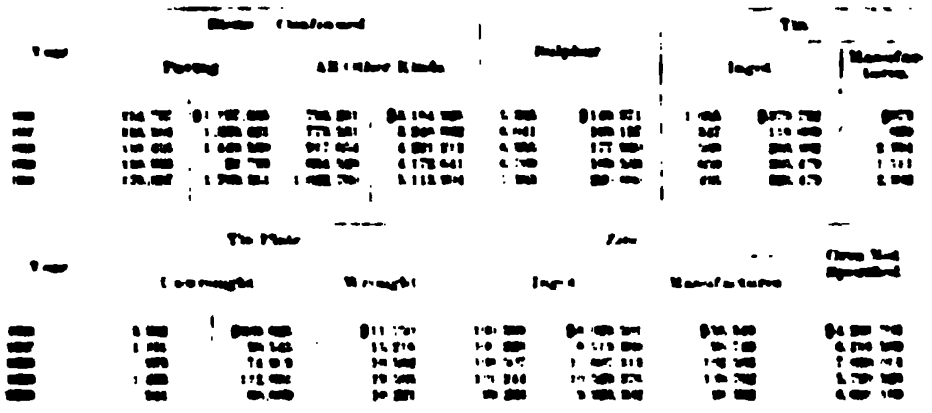
Year.	Gold (Including Platinum). Unwrought—Kg.		Coin.	Jewelry, etc.	Guano.		Iron and Steel Filings.		Iron. Ore.	
1896	2,713	2,557,514	$2,666,690	$75,570	14,633	$585,306	7,095	$59,007	389,235	$739,546
1897	2,547	1,754,374	605,120	126,395	14,044	505,585	534	4,595	410,817	780,552
1898	1,381	917,213	578,120	118,997	21,686	778,542	407	3,581	384,047	729,693
1899	504	347,758	698,200	118,916	18,213	655,669	289	2,270	318,415	636,830
1900	549	378,151	613,180	161,155	14,204	511,339	121	1,210	420,179	882,376

Year.	Iron.—Continued. Pig.		Old.		Hammered, Drawn or Rolled.		Manufactures.		Lead. Pig.	
1896	88,405	$1,189,480	18,416	$235,795	343,072	$9,072,611	44,952	$3,497,287	31,366	$1,725,144
1897	48,554	1,295,359	17,590	226,911	356,895	10,097,954	43,114	3,389,400	35,988	2,159,298
1898	16,780	223,453	23,226	309,076	294,562	4,155,448	51,980	4,151,200	40,302	2,563,246
1899	43,804	1,418,941	32,504	487,557	395,878	10,955,380	59,054	4,879,080	41,618	2,871,642
1900	35,818	1,317,952	43,736	699,778	270,594	9,158,580	65,279	6,122,112	46,566	3,818,425

Year.	Lead.—Con. Wrought.		Lime.		Petroleum. Crude.		Refined.		Resins and Bitumens, not Specified.	
1896	$36,821		477,213	$940,110	2	$23	99,321	$996,913	86,906	$4,345,315
1897	33,986		520,588	1,035,909	1	15	18,088	586,067	92,591	4,629,538
1898	16,450		546,199	1,092,399	782	13,256	19,556	657,067	107,806	5,390,353
1899	37,022		537,357	1,182,186	2,146	42,924	25,970	934,937	112,302	5,019,622
1900	8,959		617,666	1,389,749	1,759	36,988	21,812	807,096	97,970	4,898,475

Year.	Salt. Crude.		Refined.		Silver. Ore—Kg.		Bullion—Kg.		Coin—Kg.		Jewelry, etc.
1896	1,434	$8,604	129	$1,987	19,400	$9,398	40,118	$1,043,068	16,696	$667,840	$157,137
1897	493	2,959	231	2,309	423,160	42,316	57,983	1,158,660	521	20,851,320	189,959
1898	998	1,749	396	3,864	595	59	107,395	2,125,700	327	13,083,640	127,194
1899	506	3,037	885	8,850	116	12	54,358	1,087,160	337,079	13,483,160	214,175
1900	2,345	14,070	799	7,989	.....	.....	38,331	766,619	32,021	1,304,840	108,121

Year.	Steel. Ingot.		Bars, Sheets and Wire.		Manufactures.		Stone. Roofing Slate. 1,000 Pieces.		Building Stone, Including Marble and Alabaster		Cut, Polished, etc.
1896	1,143	$33,972	179,873	$4,597,877	38,306	$7,843,777	15,435	$111,139	161,288	$1,290,307	$982,147
1897	1,201	32,302	183,286	4,842,221	37,353	7,764,848	17,304	138,432	187,120	1,591,652	994,258
1898	1,018	19,397	173,949	4,956,964	33,658	6,464,309	16,945	152,504	178,369	1,782,690	981,815
1899	1,259	26,036	155,815	4,038,643	31,194	6,151,739	15,300	137,700	164,992	2,144,896	940,660
1900	974	22,793	146,121	4,854,049	28,877	5,170,992	19,996	199,960	171,326	2,226,238	672,282



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CANADA.

THE mineral statistics of the Dominion of Canada as collected by the Geological Survey and the Bureaus of Mines of the various provinces, are summarized in the following tables:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS)

Year.	Arsenic.		Asbestos and Asbestic.		Barytes.		Cement—*Barrels.* Natural Rock.		Cement—*Barrels.* Portland.		Chromite.	
1898....	*Nil.*	.....	21,577	$486,227	971	$5,258	87,125	$73,412	163,084	$324,168	1,883	$34,232
1899....	52	$4,872	22,938	483,299	653	4,402	141,387	119,508	255,366	513,983	1,796	25,780
1900....	275	22,725	27,797	763,431	1,207	7,575	125,428	99,994	292,124	545,696	2,118	27,000
1901....	680	41,076	36,475	1,259,759	592	3,842	133,328	94,415	317,066	565,615	1,159	16,744
1902....	726	48,000	36,668	1,203,452	909	3,957	124,400	91,870	594,594	1,088,618	816	12,400

Year.	Clay. Fire Clay.		Clay. Pottery	Clay. Terra-Cotta.	Clay. Tile and Sewer Pipe. (*d*)	Coal.		Coke. (*e*)		Copper (In Ore, etc.). (*f*)	
1898....	51,969	$5,000	$135,000	$167,902	$166,421	3,785,408	$8,227,958	65,721	$219,200	8,146	$2,159,556
1899....	543	1,295	200,000	220,258	161,546	4,142,242	10,283,497	91,463	350,022	6,840	2,655,319
1900....	1,129	4,130	200,000	259,450	231,525	5,088,148	13,290,429	142,555	649,140	8,582	3,065,922
1901....	3,610	5,920	200,000	278,671	250,000	5,649,417	12,005,565	339,043	1,298,225	17,158	6,096,581
1902....	2,487	4,283	200,000	348,597	294,465	6,930,287	15,538,611	459,468	1,538,980	17,766	4,553,695

Year.	Feldspar.		Gold—Kg. (*h*)		Graphite.		Grindstones.		Gypsum.		Iron Ore.	
1898....	2,268	$6,250	20,613	$13,700,000	(*q*)	$11,098	(*q*)	$39,465	198,908	$220,440	52,763	$152,510
1899....	2,722	6,000	31,673	21,049,730	1,105	24,179	4,092	43,265	221,869	257,329	62,997	248,373
1900....	288	1,112	42,008	27,916,752	1,744	31,040	5,034	53,450	228,614	259,000	∫ 32,108	583,138
1901....	4,854	14,548	36,808	24,462,222	2,005	38,780	4,156	45,690	266,605	340,148	75,408	1,212,113
1902....	6,873	11,375	.....	20,741,245	993	28,500	5,587	48,400	301,229	356,317	s389,115	1,065,019

Year.	Lead (In Ore, etc.). (*k*)		Lime—*Bushels.*		Manganese Ore.		Mica.	Mineral Paints. (Ochers.)		Mineral Waters.
1898....	14,477	$1,206,399	(*q*)	$650,000	45	$1,600	$117,598	2,124	$18,600	$155,000
1899....	9,917	977,250	(*q*)	800,000	279	3,960	163,000	3,555	19,900	100,000
1900....	28,654	2,760,521	(*q*)	800,000	(*q*)	.....	166,000	1,783	15,398	75,000
1901....	23,542	2,249,387	(*q*)	830,000	399	4,820	160,000	2,026	16,735	100,000
1902....	10,433	935,870	.....	.....	76	2,774	400,000	4,495	30,495	100,000

Year.	Natural Gas.	Nickel (In Ore, etc.). Kg. (*r*)		Petroleum, Crude. *Barrels.* (*m*)		Phosphate (Apatite).		Platinum.	Pyrites.	
1898	$320,000	2,502,808	$1,820,838	700,790	$981,106	605	3,665	(*q*)	29,228	$128,872
1899.....	387,271	2,605,461	2,067,840	808,570	1,202,020	2,722	18,000	$825	25,117	110,748
1900.....	417,094	3,212,497	3,327,707	710,498	1,151,007	1,284	7,102	(*q*)	36,316	155,164
1901.....	339,476	4,108,124	4,594,523	622,392	1,008,275	937	6,280	457	31,989	130,544
1902	195,932	4,850,499	5,025,503	521,485	934,740	777	4,963	.....	32,311	138,939

FRANCE.

THE official statistics of mineral production in France and her Colonies are summarized in the subjoined tables. With respect to the most important substances, reference should be made to the respective captions elsewhere in this volume.

MINERAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS; 5 f.—$1.)

Year.	Antimony Ore.		Arsenic Ore.		Asphaltum.		Barytes.		Bauxite.		Bituminous Substances. (*c*)	
1897..	4,685	$54,915	.....	.....	17,982	$146,272	3,209	$8,786	41,740	$55,211	233,328	$339,898
1898..	4,433	65,046	.....	.....	18,832	153,758	2,763	7,338	36,723	67,138	229,106	333,888
1899..	7,392	140,093	2,600	$20,800	22,100	172,380	4,058	11,594	48,215	88,987	258,449	360,657
1900..	7,843	112,908	4,705	36,557	25,228	206,998	3,635	10,483	58,530	92,596	266,474	383,429
1901..	9,857	156,834	7,491	37,972	20,391	170,083	4,145	9,530	76,620	124,168	249,655	372,998

Year.	Cement.		Clay Products.				Coal.					
			Potters' Clay.		Refractory Clay.		Coal.		Lignite.		Peat.	
1897..	976,818	$4,716,471	270,292	$243,200	318,185	$333,428	30,337,207	$66,020,171	460,422	$781,517	98,067	$253,851
1898..	1,072,025	5,359,620	260,362	213,344	295,913	348,532	31,826,127	71,701,384	529,977	929,300	104,265	301,486
1899..	1,144,271	5,733,404	310,220	272,176	367,432	375,891	32,256,148	80,412,932	606,564	1,096,181	99,230	302,637
1900..	1,147,670	5,796,320	331,396	258,717	329,561	339,951	32,721,562	98,962,114	682,736	1,487,314	95,630	286,988
1901..	1,127,206	5,609,774	341,407	249,235	293,208	345,156	31,633,300	99,868,200	691,700	1,564,200	118,433	349,131

Year.	Copper Ore.		Fluorspar.		Gypsum.				Iron Ore.		Lead-Silver Ore.	
					Crude.		Calcined.					
1897..	956	$3,645	2,722	8,160	292,753	$264,845	1,369,269	$2,458,337	4,582,236	$3,008,088	21,212	$556,261
1898..	333	2,841	3,077	9,231	303,531	281,690	1,449,394	2,596,870	4,731,394	3,207,447	23,342	640,226
1899..	2,031	64,416	5,140	15,888	283,879	261,192	1,373,067	2,475,616	4,985,702	3,640,115	17,505	543,146
1900..	3,061	151,090	3,430	10,341	192,916	192,679	1,405,845	2,579,542	4,676,740	3,545,312	24,276	721,716
1901..	3,413	112,784	3,970	11,554	355,995	338,536	1,625,710	3,111,211	4,260,747	3,111,422	20,644	562,963

Year.	Lime.		Manganese Ore.		Millstones.		Mineral Paints. (Ochers.)		Petroleum, Crude.		Phosphate Rock.	
1897..	2,201,498	$5,692,338	37,212	$208,035	32,175	$244,083	32,299	$156,180	10,233	$234,811	535,390	$2,854,887
1898..	2,339,850	5,975,874	31,935	166,211	g38,929	727,235	33,780	158,014	9,694	221,172	568,558	3,115,958
1899..	2,342,377	6,061,929	39,897	223,337	41,535	765,242	32,750	161,473	(*b*)	.....	645,868	3,334,145
1900..	2,377,110	6,330,198	28,992	170,089	41,103	730,234	33,080	164,000	(*b*)	.....	587,919	2,827,291
1901..	2,442,068	6,577,454	22,304	95,025	33,286	290,913	35,704	275,930	(*b*)	.....	535,676	2,614,543

Year.	Pyrites.		Salt.		Slate.				Stone.	
					Roofing.		Slabs.		Building.	
1897..	206,466	$752,658	948,003	$2,239,824	310,820	$3,630,949	1,143	$31,282	10,105,438	$9,355,103
1898..	210,972	785,942	999,263	2,115,120	316,911	4,118,789	1,318	38,552	9,989,416	9,890,737
1899..	316,822	957,023	1,193,522	2,506,832	299,307	3,615,362	1,162	36,003	10,587,789	10,445,644
1900..	305,073	779,925	1,088,634	2,415,973	290,304	3,439,961	1,325	39,400	9,974,347	9,612,391
1901..	307,447	796,056	910,000	2,012,800	288,508	3,439,495	1,304	38,560	10,277,096	9,737,812

Year. (h)	Gravel and Sand.		Iron and Steel. (f)	Kainite.		Lead. (f)	Lead Pigments and Zinc White.		Lime. No. of Bbls.		Litharge.	
1898..	29,164	$43,297	$16,407,644	49	$1,008	$335,278	5,758	$446,639	12,859	$9,682	519	$32,304
1899..	27,477	42,219	19,709,725	30	777	309,450	6,581	514,842	15,739	11,194	432	32,518
1900..	32,309	41,290	27,423,910	143	2,339	322,446	6,054	634,692	12,895	11,211	415	29,176
1901..	25,744	42,491	25,062,494	66	1,241	312,570	4,677	462,353	19,657	14,584	565	37,944
1902..	42,995	56,668	30,468,608	95	2,650	283,499	7,084	608,621	24,802	17,584	589	47,021

Year. (h)	Litho-graphic Stones.	Mineral Oils. Gallons.		Mineral Paints. (Ocher.)		Ores of Metals.		Phos-phorus.		Potassium Salts. Except Saltpeter.		Saltpeter.	
1898..	$7,791	8,175,006	$623,264	448	$9,428	69,766	$155,563	5	$4,618	244	$32,502	627	$51,236
1899..	6,223	9,708,169	692,447	502	10,432	61,254	153,956	1	778	472	52,177	980	65,186
1900..	6,294	8,623,094	739,266	496	10,050	61,580	282,191	1	892	733	64,538	602	52,235
1901..	9,564	10,667,755	872,696	365	7,849	84,156	598,016	5	3,436	476	59,746	581	46,504
1902..	12,272	11,811,093	930,791	444	8,982	369,072	727,099	2	580	771	77,046	690	61,559

Year. (h)	Precious Stones and Jewelry.	Pumice Stone.	Quicksilver.		Sal Ammonia.		Salt.		Silex.		Slate.
1898.....	$743,607	$3,829	27	$36,425	38	$3,721	96,965	$336,302	141	$2,773	$24,977
1899.....	928,837	5,973	47	51,695	53	5,092	88,373	300,359	180	2,595	33,100
1900.....	782,675	5,604	39	51,997	60	6,987	92,797	325,433	182	2,876	33,707
1901.....	1,279,617	5,516	64	94,564	76	9,459	98,127	339,897	162	2,106	72,164
1902.....	1,497,321	7,254	44	56,615	78	9,460	114,442	434,708	199	3,858	72,628

Year. (h)	Sodium Salts, Except Chloride.		Stone and Marble. (f)	Sulphur.		Tin. (f)	Whiting.	Zinc. (f)
1898.....	16,026	$446,799	$189,386	17,948	$373,786	$1,548,346	25 761	$135,849
1899.....	20,742	476,706	237,543	11,121	265,799	1,370,259	34,310	154,440
1900.....	16,748	458,723	250,084	9,584	215,438	2,415,636	34,575	167,662
1901.....	18,631	509,278	255 550	10,827	270,606	2,334,668	60,878	173,989
1902.....	17,133	488,698	342,571	11,180	325,307	2,343,494	42,136	148,297

MINERAL EXPORTS OF DOMESTIC PRODUCE FROM THE DOMINION OF CANADA. (a) (IN METRIC TONS AND DOLLARS.)

Year. (h)	Antimony Ore.		Asbestos.		Barytes	Clay Products. Brick. Thousands.		Clay, M'f's of.	Cement.	Cinders.	Coal.		Coin and Bullion. (g)
1898..	1,118	$15,295	16,714	$510,368	(i)	276	$1,553	$343	$609	(i)	981,696	$3,273,415	$1,045,383
1899..	(i)	.....	13,172	453,176	(i)	93	707	339	2,789	$50	1,034,963	3,562,794	1,101,945
1900..	6	900	16,478	490,909	(i)	342	2,314	215	2,274	66	1,581,422	4,771,441	1,670,068
1901..	219	5,074	26,715	864,573	3,830	738	5,807	761	3,554	10	1,998,538	5,307,080	1,978,469
1902..	13	2,170	30,011	1,131,902	(i)	660	5,581	414	1,359	75	1,648,852	4,867,088	1,669,430

Year. (h)	Coke.		Copper. (c)		Explo-sives.	Fertil-izers.	Glass and Glass-ware.	Graphite.		Grind-stones.	Gypsum. Crude.		Ground	Iron and Steel. M'f's of
1898..	3,275	$7,341	4,218	$832,546	92	$74,305	$46,864	$7,494	348	$6,428	$18,785	163,612	$193,515	2,587	$906,092
1899..	4,024	15,084	3,812	917,429	151	115,065	51,224	11,788	662	12,749	18,619	148,525	166,222	7,611	706,411
1900..	12,538	33,770	6,272	1,387,218	212	155,764	51,410	11,016	1,742	30,054	22,196	211,794	236,084	2,622	1,425,173
1901..	60,129	192,910	11,998	2,655,467	434	340,585	57,706	13,574	1,246	40,099	38,304	172,010	185,208	25,472	1,492,961
1902..	52,873	184,499	13,790	2,990,094	331	248,434	61,831	11,587	783	25,789	21,878	243,880	273,335	19,150	2,460,781

Year.	Cement—No. of Barrels. Natural Rock.	Portland	Copper.	Gold. Metal. Kg.	Gold. Metal. Value.	Graphite.	Gypsum, Crude and Calcined
1898	91,520	$74,222	153,340	$262,956	2,738	$260,190	565	$25,674	272	$6,998	2,722	$4,900
1899	170,487	117,989	222,550	444,227	2,571	176,287	1,164	679,224	1,316	14,179	1,969	15,512
1900	125,429	99,504	206,726	589,921	3,052	319,951	583	287,951	1,695	27,000	988	19,950
1901	179,029	147,925	721,000	573,225	4,117	549,010	446	244,442	987	20,000	1,400	13,600
1902	.....	50,725	.....	916,221	.....	695,042	.....	220,000	.....	17,000	.....	19,149

Year.	Iron. Ore.		Iron. Pig.		Lime—Bushels.		Mica.		Natural Gas.	Nickel.		Petroleum. Crude. Imperial Gallons. (h)	
1898	24,395	$48,977	43,775	$520,799	2,620,000	$708,000	31	$7,500	$301,600	2,071	$514,220	26,978,977	(g)
1899	15,342	30,951	54,740	908,157	4,342,500	535,000	241	38,000	440,904	2,605	598,104	23,615,967	(g)
1900	61,981	111,905	56,500	926,056	2,402,000	544,000	552	61,550	392,622	3,211	756,626	23,341,783	$1,869,045
1901	207,300	174,499	105,500	1,701,766	4,100,000	550,000	267	37,219	336,168	4,080	1,859,970	21,453,500	1,467,940
1902	.....	.....	.....	.....	.....	617,000	.....	.....	.....	.....	2,210,951	.....	1,600,000

Year.	Petroleum.—Continued. Refined Products. (h) Illuminating Oils. Imp. Gals.		Lubricating Oils. Imp. Gals.		All Other Oils. Imp. Gals. (c)		Paraffine Wax. Metric Tons.		(e) Fuel Products.	Salt.	
1898	12,391,022	$1,243,490	2,043,226	$302,150	1,240,907	$121,840	1,186·6	$116,849	$296,705	53,874	$278,886
1899	11,697,910	1,059,485	2,087,475	189,294	1,394,530	148,963	1,266·8	136,066	213,544	51,143	317,412
1900	11,793,755	1,076,242	1,980,428	282,805	1,463,509	174,546	2,086·4	164,718	200,934	60,408	327,477
1901	9,463,302	798,140	764,861	78,975	1,075,999	122,781	1,582·8	165,892	139,753	54,744	333,058
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	344,020

Year.	Sewer Pipe.	Silver. Kg.	Silver. Value.	Stone. Total Value.	Total Value. (f)
1898	$98,717	2,003·5	$51,960	$750,000	$7,201,891
1899	138,356	3,280·4	65,575	1,041,850	8,785,351
1900	130,635	4 905·9	96,367	650,842	9,242,044
1901	147,048	4,916·2	84,830	850,000	11,892,595
1902	191,965	.....	80,000	.....	.....

(a) From the *Annual Reports of the Bureau of Mines of Ontario*, Toronto. (b) Quantity and value included with that of plain pressed brick. (c) Comprises benzine and naphtha. (e) Comprises gas and fuel oils and tar. (f) In 1898 total includes 521 metric tons calcium carbide ($34,440). In 1899, 5,300,000 paving brick ($42,550); 965 metric tons calcium carbide ($74,680); 91 metric tons of talc ($500); and 1,069 metric tons of zinc ($94,000). In 1900, 454 metric tons zinc ore ($500); 3,211 tons steel ($756,626); 3,629 tons feldspar ($5,000); 907 tons talc ($5,000). In 1901, 1,361 metric tons zinc ore ($1,500); 13,131 tons steel ($347,280); 4,698 tons feldspar ($40,375); 363 tons talc ($1,400;) 6,353 tons iron pyrites ($17,500;) 485 tons corundum ($53,115); 2,515 tons calcium carbide ($168,792); 473 tons actinolite ($3,126). (g) Not reported. (h) One barrel of crude oil is reckoned at 35 imperial gallons, and 1 barrel refined at 42 imperial gallons.

MINERAL PRODUCTION OF QUEBEC. (a) (IN METRIC TONS AND DOLLARS; $1 = $5.)

Year.	Asbestos.		Chrome Ore.		Copper Ore.	Gold.—Kg.		Granite.		Graphite.		Total Value. (c)
1899	21,106	$615,140	1,796	$21,440	39,654	$166,500	8·4	$5,050	.....	.....	55	$5,240	$2,142,400
1900	26,619	755,510	2,101	85,735	34,268	154,965	.....	.....	.....	.....	364	9,725	1,469,750
1901	36,555	1,319,630	1,155	17,205	18,411	129,965	9·5	1,480	.....	$150,000	76	4,880	1,573,630
1902	b 33,649	1,174,708	816	13,500	28,974	121,170	9·3	5,400	.....	160,000	22	2,160	2,985,463

(a) From *Reports on the Mines of the Province of Quebec*. (b) Includes 6,858 metric tons asbestic ($12,738). (c) Includes, in 1902, 1,000,000 bu. lime ($140,000); 120,000,000 bricks ($600,000); stones ($30,000).

CHILE.

There are no official statistics of mineral production in Chile. The exports [illegible] are summarized in the following tables. With respect to the most important articles of mineral production, that is, copper and nitrate of soda, the exports practically represent the production. This is also the case with [illegible] and borate of lime.

[illegible]

[illegible]

[illegible]

[illegible]

Year.	Silver, in Bars, etc. Kg.		Silver, Old. Kg.		Silver-Lead Ore.		Silver Sulphuret Ore.		Tin.	
1897....	143,541	$3,781,125	443	$12,518	6·0	$636	168	$336,992	46	$54,619
1898....	139,756	6,997,816	55	2,219	11·8	1,557	280	424,740	6	4,999
1899....	75,899	3,731,599	(b)	.....	32·0	4,544	339	1,017,110	6	4,979
1900....	45,623	2,506,497	140	5,322	1·4	218	172	653,332	0·2	108
1901....	46,164	2,690,049	3,467	204,753	.....	.....	264	672,779	4·0	2,694

(a) From the *Estadistica Commercial de la Republica de Chile*, Valparaiso. It will be noticed that the values reported vary widely for the different years. This is probably to be referred to the fluctuations of the currency standard. (b) Not reported. There was also exported: In 1901, gold precipitate, 289 kg., $635,179.

MINERAL IMPORTS OF CHILE. (a) (IN METRIC TONS AND CHILEAN DOLLARS.)

Year.	Bitumen for Pavements.		Brass.		Cement, Roman.		Coal.		Copper.			
									Sheets.		For Various Uses	
1897....	237	$55,892	60	$26,206	18,205	$365,129	513,421	$4,122,918	55	$28,383	43	$23,894
1898....	88	52,473	.....	.....	16,905	676,199	656,202	12,173,965	57	44,002	.....	.....
1899....	84	62,988	*Nil.*	.....	16,166	646,566	622,527	12,469,478	75	57,343	.....	.....
1900....	120	98,089	*Nil.*	.....	20,370	814,672	674,748	13,494,960	104	77,582	.....	.....
1901....	*Nil.*	.....	59	47,998	22,355	896,409	719,400	14,388,000	188	146,682	.....	.....

Year.	Copper, Sulphate.		Earth for Smelting Furnaces.		Gold Coin.	Iron.						
						Bars and Ingots.		Hoops.		Sheets, Ungalv.		Sheets, Galv.	
1897....	95	$10,787	100	$3,542	$4,440	7,604	$354,592	802	$63,943	1,899	$153,782	10,757	$1,292,176
1898....	218	65,358	30	1,795	*Nil.*	10,223	1,256,190	404	54,208	2,253	282,253	9,946	1,277,263
1899....	188	56,312	25	1,178	*Nil.*	8,294	870,768	913	120,831	2,553	284,995	3,337	385,250
1900....	121	35,970	97	5,547	*Nil.*	9,817	1,034,237	1,271	149,357	2,757	338,608	8,096	1,131,777
1901....	118	33,941	120	7,196	*Nil.*	5,559	291,902	866	107,061	3,651	444,526	9,500	1,341,595

Year.	Lead, Bars and Sheets.		Quicksilver.		Salt.				Silver.				
					Common.		Refined.		Bars—Kg.		Coin.	Ore.	
1897....	281	$37,889	40	$39,758	13,179	$90,742	330	$16,191	.....	.....	$36,980	9	$3,699
1898....	118	28,239	15	44,485	1,543	30,865	101	10,111	.....	.....	*Nil.*	21	5,465
1899....	70	16,742	21	63,806	397	7,971	38	3,893	.....	.....	*Nil.*	1	65
1900....	205	51,205	9	27,818	.....	.....	.....	.....	11 1	$552,700	*Nil.*	3	19
1901....	188	33,045	1	2,481	.....	.....	.....	.....	*Nil.*	.....	*Nil.*	*Nil.*	.....

Year.	Soda, Caustic.		Steel, Bars and Sheets.		Sulphur.		Tin.		Whiting and Gypsum.		Zinc.			
											Bars.		Sheets.	
1897....	2,604	$155,020	2,925	$208,181	2,655	$157,671	608	$82,149	492	$13,663	24	$3,314	222	$29,225
1898....	2,790	241,700	1,369	166,268	3,317	281,725	51	58,173	466	22 098	73	18,213	282	36,226
1899....	1,135	141,461	1,686	208,633	306	30,694	45	57,059	410	20,782	104	33,133	79	24,697
1900....	1,415	147,258	3,758	451,450	1,353	135,848	49	65,946	966	48,371	158	47,399	351	107,695
1901....	980	127,253	4,290	531,656	1,494	149,421	77	85,099	487	24,385	b746	196,301	.....	.....

(a) From the *Estadistica Commercial de la Republica de Chile*, Valparaiso. (b) Includes sheet.

CHINA.

[illegible] are no official statistics of mineral production in China. The exports and imports as reported by the Imperial Maritime Customs officials are summarized in the following tables:

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]										
[illegible]										
[illegible]										
[illegible]										

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
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[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]										
[illegible]										
[illegible]										
[illegible]										

Year.	Metals, Unclassed.	Nickel.		Paints.	Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.	
1897...	$197,650	25·9	$22,324	$487,602	451,387,562	$6,571,574	55·1	$54,688	1,429·1	$146,436
1898....	247,245	67·9	63,352	503,059	391,720,570	4,301,595	70·4	67,491	622·1	77,894
1899....	260,873	106·2	69,569	540,561	338,653,220	3,491,710	51·5	52,305	1··	76,745
1900.....	449,196	75·5	69,163	607,339	334,281,190	10,686,056	55·2	66,854	234·2	23,455
1901.....	229,287	62·7	56,370	522,206	284,474,184	12,651,388	61·7	54,279	77·7	9,531

Year.	Steel.			Tin.			White Metal, German Silver.		Yellow Metal, Bar, Rod, Sheets, and Nails.	
	Crucible.		Mild, or Iron Ingots.	Plates.		Slabs.				
1897...	2,388·9	$158,456	711·6	$22,223	2,543·7	$260,447	4,125·9	$1,386,262	241·6	$122,901	1,753·6	$317,157
1898....	2,290·7	178,523	2,169·9	232,765	6,776·6	695,659	3,715·5	1,131,629	230·4	134,559	1,678·4	297,903
1899....	5,185·9	323,996	5,000·2	325,599	1,121·7	76,264	2,262·4	1,068,765	162·6	84,589	1,566·2	325,610
1900.....	3,715·9	274,977	6,511·1	392,652	2,182·9	225,471	3,329·7	1,459,998	155·7	94,096	1,466·6	333,334
1901.....	3,199·3	216,589	7,973·2	251,956	4,992·4	419,090	4,266·2	2,089,351	176·2	109,577	1,442·0	297,442

RE-EXPORT OF FOREIGN GOODS FROM CHINA. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Cement.		Chinaware.		Coal.		Colors.		Copper, Bar, Rod Sheets, Plates and Nails.		Glass. Window. *Boxes.*		Glass. Wares.
1897...	147·0	$1,585	0·1	$123	47,254	$235,561	35·8	$8,578	5·08	$1,008	1,024	$2,580	$1,992
1898....	182·4	2,094	0·1	81	55,228	284,501	(b)	5,880	(d) 1·98	517	1,373	3,459	2,675
1899....	57·6	660	0·2	40	64,259	347,305	(b)	7,997	(d) 6·42	2,275	683	1,901	2,014
1900.....	(b)	128	0·7	102	54,205	267,513	(b)	4,784	(d)27·09	9,795	2,310	6,705	3,141
1901.....	(b)	20,744	(b)	.....	65,053	309,777	(b)	4,264	(d)72·36	17,454	5,460	15,292	1,536

Year.	Iron. Bar, Hoop, Nail-Rod, Sheets, Plates, and Wire.		Iron. Old.		Iron. Pig and Kentledge.		Iron. Wares, Unclassed.	Lead—In Pigs.		Metals, Unclassed.
1897....	1,601·5	$49,055	258·5	$5,098	1,181·6	$33,774	$6,340	66·6	$4,981	$5,650
1898....	1,155·9	57,249	342·5	7,467	707·1	19,650	11,000	72·7	5,894	12,098
1899....	1,166·9	57,814	365·0	7,185	2,860·1	67,177	7,654	0·1	10	5,279
1900.....	1,035·0	62,097	323·6	6,518	244·4	5,859	10,297	82·2	2,837	9,396
1901.....	830·5	49,506	275·4	6,394	171·8	3,614	4,973	0·6	45	28,840

Year.	Nickel.		Paints.	Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.		Steel.	
1897.....	3·448	$1,874	$15,996	1,982,607	$42,628	2·6	$2,689	12·08	$1,132	591·0	$80,695
1898.....	4·664	2,952	15,016	2,585,556	59,441	4·1	4,096	(b)	.....	789·6	28,179
1899.....	1·912	772	22,718	50,160	1,505	1·0	1,177	(b)	.....	615·6	23,550
1900.....	27·879	17,856	18,674	1,971,900	68,686	3·9	4,881	(b)	.....	429·2	21,144
1901.....	4·908	3,155	7,199	643,850	18,759	1·7	2,056	(b)	.....	582·1	26,950

RE-EXPORT OF FOREIGN GOODS FROM CHINA. *Concluded.*

Year.	White Metal. (German Silver)		Tin, in Slabs and Tinplates.		Yellow Metal, Bar, Rod, Sheets and Nails.	
1897....	1·3	$711	271·1	$32,430	0·2	$53
1898....	0·2	91	127·5	27,999	13·6	2,928
1899....	1·2	698	701·2	73,310	1·3	468
1900.....	1·2	711	258·7	53,043	0·06	21
1901.....	0·8	433	298·9	34,752	0·25	45

EXPORT OF NATIVE GOODS FROM CHINA. (c) (IN METRIC TONS AND DOLLARS.)

Year.	Chinaware, Earthenware, and Pottery.		Glassware, Bangles, etc.		Gold and Silver Ware.	
1897...	30,453	$996,722	1,066·9	$252,573	2·597	$68,575
1898....	30,381	1,053,015	1,261·9	310,919	3·385	112,539
1899...	22,605	1,316,082	1,945·1	313,712	3·574	126,252
1900.....	21,396	1,220,586	1,065·4	279,976	4·382	125,748
1901...	20,396	1,218,544	1,163·9	286,857	4·558	136,956

(a) From the *Returns of Trade and Trade Reports of the Imperial Maritime Customs, Shanghai, China.* In these reports the unit of quantity is chiefly the "picul," and that of value the "Haikwan-tael." In converting the original data to metric tons and dollars, the following relations were used: 1 picul = 0·059653 metric ton; in 1897, 1 Haikwan tael = 72c.; in 1898, 70c.; in 1899, 71·4c.; in 1900, 71·2c.; in 1901, 70·2c., at the average sight exchange on New York, London, Paris, Berlin, Calcutta, and Hong-Kong respectively. (b) Not reported. (c) In 1898 there was also exported 4·41 metric tons of unclassed copperware valued at $3,280; in 1900, 0·25 metric tons ($153); in 1900, 0·42 metric tons ($213); in 1901, 0·12 metric tons ($60).

FRANCE

Stone—Continued.

Year.	Limestone. (Flux.)		Marble.		Paving Blocks.		Sulphur Ore. d		Zinc Ore.	
1897....	709,502	$159,777	113,675	$227,134	569,657	$1,[illegible]	[illegible]	[illegible]	98,944	$1,305,013
1898....	666,201	250,000	124,161	248,321	592,892	1,[illegible]	[illegible]	[illegible]	95,530	1,673,581
1899....	224,245	246,845	191,169	1,[illegible]	821,720	2,[illegible]	[illegible]	[illegible]	94,913	1,915,402
1900....	1,040,916	256,251	154,414	1,225,166	659,125	2,[illegible]	[illegible]	[illegible]	47,080	1,222,280
1901....	1,060,372	277,047	123,246	962,010	604,064	2,147,950	7,400	14,800	61,520	654,595

METALLURGICAL PRODUCTION OF FRANCE. (a) (IN METRIC TONS; 5 f.—$1.)

Year.	Aluminum.		Antimony.		Copper.		Gold—Kg.		Iron and Steel. Iron, Pig.		Iron, Wrought.	
1897....	470	$296,500	1,099	$141,957	7,376	$1,945,243	276	$190,109	2,494,191	$39,121,027	584,540	$24,405,854
1898....	595	391,900	1,225	163,200	7,524	2,270,200	257	183,200	2,525,100	31,858,400	766,000	25,221,800
1899....	700	401,500	1,400	243,900	6,640	2,419,000	270	195,000	2,578,400	37,342,000	834,000	30,765,400
1900....	1,026	625,000	1,573	246,000	6,446	2,365,000	293	179,000	2,714,298	44,318,800	672,172	33,063,400
1901....	1,200	600,000	1,795	240,000	7,000	2,204,200	129	66,000	2,388,823	34,366,124	612,368	27,657,447

Year.	Iron and Steel Cast Steel. (c)		Lead. (f)		Nickel.		Silver—Kg.		Zinc.	
1897.....	994,801	$45,276,659	9,916	$630,928	1,245	$741,500	80,351	$1,639,160	38,067	$3,263,600
1898.....	1,174,000	55,042,800	10,920	788,400	1,540	920,000	90,583	1,817,000	37,155	3,536,000
1899.....	1,240,000	64,877,400	15,981	1,343,500	1,740	1,040,000	82,105	1,642,100	39,274	4,508,400
1900.....	1,226,587	70,813,000	15,210	1,253,320	1,700	1,020,000	85,646	1,712,920	36,305	3,569,680
1901.....	1,175,454	58,704,112	21,000	1,451,600	1,800	1,440,000	76,521	1,530,420	37,600	3,256,000

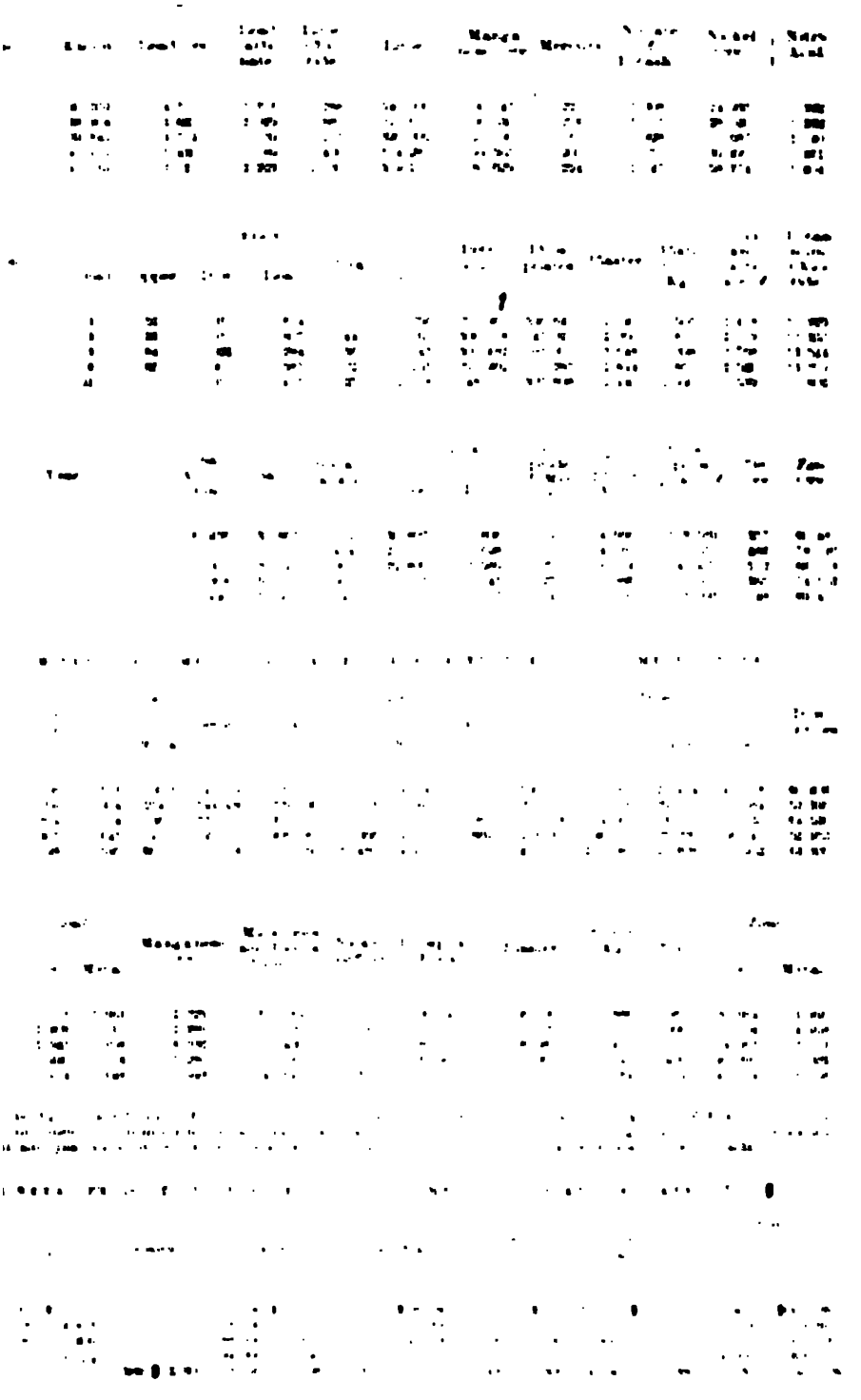
(a) From *Statistique de l'Industrie Minérale*. (b) Not reported. (c) Includes pure bitumen, bituminous schist, bituminous sand, and asphaltic limestone. (d) Sulphur and limestone impregnated with sulphur. (e) Wrought steel. (f) Lead produced from native ores only, and does not include the metal produced from foreign ores and bullion. (g) Finished product.

MINERAL IMPORTS OF FRANCE. (a) (IN METRIC TONS; 5 f.—$1.)

Year.	Bituminous Substances. (b)		Coal. (c)		Copper.		Gold.	Silver.	Iron and Steel.		Iron, Cast. (Crude.)	
1898..	80,885	$944,600	10,445,000	$41,438,200	52,076	$14,998,000	$39,881,575	$38,274,504	47,325	$1,941,600	(d)	$998,000
1899..	80,770	909,200	11,896,000	51,640,600	58,419	20,450,000	63,607,020	37,528,657	64,178	3,283,400	(d)	2,182,200
1900..	80,598	475,200	14,001,981	81,300,600	61,638	21,628,800	90,408,728	29,164,546	118,152	5,797,800	149,755	3,748,400
1901..	98,888	846,600	18,026,623	68,558,400	47,035	15,442,600	85,485,000	19,557,600	77,742	2,945,000	61,085	1,329,200
1902..	96,058	812,600	18,137,720	67,016,000	54,484	18,098,600	88,091,400	19,343,400	60,697	2,251,600	38,531	943,800

Year.	Lead.		Nickel.		Sodium Nitrate.	Stone.	Sulphur.		Tin.		Zinc.	
1898..	74,909	$5,843,600	330	$525,000	$8,026,400	$2,814,600	130,289	$2,800,400	9,247	$3,475,800	32,342	$3,692,400
1899..	67,149	6,657,400	298	399,600	9,341,000	4,404,800	120,062	2,813,000	6,907	4,495,400	25,516	3,467,600
1900..	70,887	7,749,200	290	397,740	11,905,820	5,282,200	133,531	3,140,200	7,324	5,055,800	33,144	3,916,800
1901..	59,051	4,709,800	252	541,200	10,526,400	4,670,200	101,301	2,369,000	7,314	4,775,200	29,812	2,950,000
1902..	58,694	4,788,400	301	457,000	9,372,600	4,870,600	85,839	1,806,000	8,575	5,568,200	36,564	3,511,000

Year.	Alum.	Borax	Bromides.	Cement	Chromate of Potash and of Soda.	Copper Ore.	Hydrochloric Acid.	Iron. Ore.	Iron. Pyrites.
1898.....	27	139	30	11,230	2,890	8,779	1,994	2,082,240	71,360
1899.....	34	123	46	13,640	3,147	8,517	1,905	1,950,685	100,000
1900.....	23	111	10	13,612	3,298	9,706	1,998	2,119,008	126,425
1901.....	39	129	3	16,228	2,784	13,268	1,908	1,[illegible]55	205,670
1902.....	36	141	3	15,721	2,251	11,980	2,[illegible]	1,[illegible]84	170,720



Year.	Iron—Con. Cast. 24 Furn.		Lead-Silver Ore.		Lime. Hydraulic		Lime. White.		Marble.		Onyx.	
1897	699	$44,970	145	$3,041	20,625	$122,500	9,215	$32,260	1,000	$30,150	354	$25,490
1898	*Nil.*	.....	120	3,120	13,000	78,000	12,975	46,758	985	30,864	251	12,843
1899	*Nil.*	.....	249	10,482	12,000	72,000	11,645	44,963	225	428	277	12,357
1900	*Nil.*	.....	222	6,992	12,000	72,000	12,700	49,050	....	.....	254	12,576
1901	*Nil.*	.....	1,614	21,916	12,000	72,000	15,400	55,500	....	.....	254	14,758

Year.	Phosphate Rock.		Quicksilver Ore.		Salt.		Sand and Gravel.		Zinc Ore.	
1897	228,141	$912,564	.....	.....	23,222	$78,656	80,980	$30,240	32,979	$301,538
1898	269,500	1,078,000	.....	.....	21,300	85,000	72,185	17,717	29,400	261,400
1899	324,998	1,299,992	.....	.....	17,378	67,300	72,760	15,927	42,979	302,579
1900	319,422	1,277,688	.....	.....	18,925	76,268	71,950	14,569	30,281	267,394
1901	265,000	1,060,000	.....	.....	18,516	79,976	86,727	18,970	26,913	282,358

(a) From *Statistique de l'Industrie Minérale.* (b) Copper ore.

MINERAL EXPORTS OF NEW CALEDONIA. (a) (IN METRIC TONS.)

Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1897	3,949	3,200	2,200	26,464
1898	7,712	2,373	*Nil.*	74,614
1899	12,634	3,294	6,349	108,908
1900	10,474	2,495	2	100,319
1901	17,451	3,123	6,349	133,814

(a) From *Statistique de l'Industrie Minérale.* Additional products in 1897: Lead ore, 200 metric tons.

MINERAL PRODUCTION OF TUNIS. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Salt.		Lead Ore.		Zinc Ore.	
1897	8,100	$32,400	2,123	$26,060	11,880	$147,200
1898	7,800	33,200	2,875	37,680	21,477	185,520
1899	8,800	35,400	2,963	53,400	20,079	313,400
1900	9,100	64,120	6,864	122,200	16,596	221,600
1901	16,000	74,800	8,158	133,800	17,879	216,200

(a) From *Annual General Reports*, by C. Le Neve Foster, and *Statistique de l'Industrie Minérale.* Additional products in 1898, 70,000 tons phosphate rock, valued at $168,000; in 1900, 178,000 tons, valued at $781,000; in 1901, 172,000 tons, valued at $538,600.

GERMANY

Year.	Pyrites.		Salt.		Salt, Rock.		Silver and Gold Ore.		Silver—Kg.	
1898....	136,849	$242,586	565,683	$3,116,087	804,658	$838,656	12,413	$336,657	480,578	$9,539,162
1899....	144,623	259,250	571,058	3,021,750	861,123	957,000	13,506	479,750	467,590	9,458,000
1900....	169,447	303,750	587,464	3,567,000	926,563	1,060,500	12,593	514,500	415,735	8,698,250
1901....	157,433	285,500	578,761	3,932,500	985,050	1,132,250	11,577	387,750	403,796	8,129,750
1902....	165,225	321,250	572,846	3,902,750	1,010,412	1,171,000	11,624	346,000	430,610	7,700,000

Year.	Sodium Salts. (Glauber Salt.)		Sulphur.		Sulphuric Acid. (g)		Sulphates. (d)							
							Copper.		Iron.		Zinc.		Copper and Iron Mixed.	
1898....	69,111	$452,509	1,954	$43,167	664,865	$4,085,734	4,352	$356,540	10,422	$42,707	6,104	$91,152	176	$6,991
1899....	79,062	504,000	1,663	36,000	882,666	5,737,000	5,142	460,750	10,931	38,750	7,117	107,000	212	9,000
1900....	90,468	663,750	1,445	31,000	829,376	5,835,000	5,076	587,000	10,747	41,000	6,027	80,250	166	7,000
1901....	76,065	492,000	963	20,250	835,000	5,856,750	5,192	572,750	11,019	41,250	5,552	74,250	139	5,500
1902....	88,973	543,500	.....	.....	894,499	6,079,750	4,997	471,500	.....	.....	.....	.....	.....	.....

Year.	Tin		Tin Ore.		Uranium and Wolfram Ores.		Zinc.		Zinc Ore.		Vitriol and Alum Ores. Unspecified.	
1898....	993	$372,252	51	$3,550	50	$11,527	154,181	$14,708,459	641,706	$5,511,819	188	$338
1899....	1,481	870,750	72	10,000	50	13,000	153,155	18,737,750	664,536	8,955,000	533	750
1900....	2,081	1,322,750	80	11,250	43	11,250	155,790	15,516,750	639,215	6,488,250	350	500
1901....	1,451	849,000	82	12,500	43	7,500	166,233	13,696,750	647,496	5,375,500	1,056	1,500
1902....	1,986	1,161,500	.....	.....	.....	.....	174,027	15,451,000	702,504	7,452,750	.....	.....

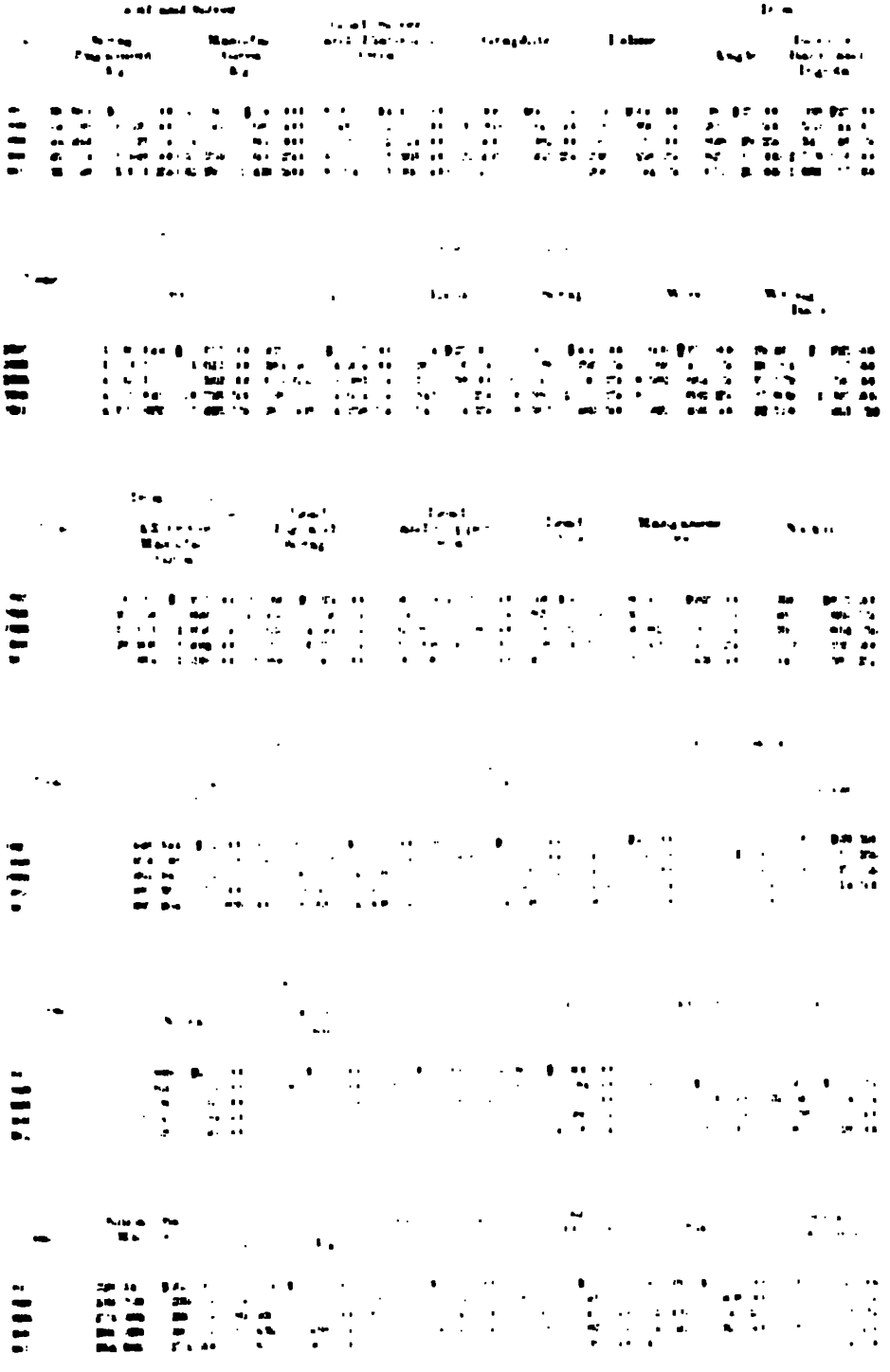
(a) Including Luxemburg. (b) From *Vierteljahrs- und Monats-hefte zur Statistik des Deutschen Reichs.* (c) Including metallic bismuth, cobalt products, and uranium salts. (d) There was also produced nickel sulphate and tin chloride as follows: 1900, 143 tons, $31,500; 1901, 135 tons, $27,250. (e) Kieserite, glauberite, etc. (f) Including quicksilver ore. (g) There was also produced fuming sulphuric acid as follows: 1900, 20,495 tons, $235,500; 1901, 21,827 tons, $255,250; 1902, 70,557 tons, $640,000.

MINERAL IMPORTS OF GERMANY. (a) (IN METRIC TONS AND DOLLARS; 4 marks= $1.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products.					
									Brick and Roofing Tile.		Porcelain.		Kaolin, Feldspar and Fire Clay.	
1897	29,633	$900,000	417	$425,000	33,113	$1,325,000	42,364	$350,000	84,477	$1,325,000	812	$357,000	207,155	$2,050,000
1898	(c)	.....	459	482,500	30,254	1,285,750	53,519	318,000	95,575	1,661,500	788	317,750	208,186	2,087,750
1899	(c)	.....	495	557,000	28,868	1,443,500	63,388	306,000	100,063	1,827,500	704	284,500	235,233	2,509,000
1900	(c)	.....	483	546,000	23,105	1,213,000	79,303	705,500	91,207	1,643,500	765	312,750	265,289	2,981,750
1901	(c)	.....	438	484,500	44,408	2,442,500	87,259	668,500	68,456	1,448,750	787	318,500	249,180	2,205,750

Year.	Coal.		Coal. (Lignite.)		Coke.		Copper.			
							Bars and Sheets.		Crude.	
1897.....	6,072,089	$16,695,000	8,111,076	$12,775,000	435,161	$1,950,000	400	$125,000	67,573	$17,085,000
1898.....	5,895,332	17,237,500	8,450,149	13,942,750	332,579	1,677,500	450	141,250	73,291	19,711,500
1899.....	6,230,489	21,350,250	8,616,751	15,079,250	462,577	2,587,750	610	251,750	70,091	26,008,250
1900.....	7,384,049	33,720,000	7,960,313	16,915,750	512,690	3,296,250	906	381,250	83,503	31,892,000
1901.....	6,997,389	23,139,500	8,108,943	18,853,250	400,197	2,278,000	786	311,750	58,620	21,265,000

Year.	Copper—*Con.*		Copper and Brass Manufactures.						Glass Manufactures, All Kinds.		Gold.			
	Scrap and Coin.		Fine.		Wire.		Cartridge Cases, Coarse Wares, etc.				Bullion. Kg.		Coin. Kg.	
1897..	4,199	$950,000	846	$700,000	80	$25,000	612	$300,000	2,057	$475,000	34,991	$24,325,000	22,914	$14,350,000
1898..	4,730	1,153,500	881	791,000	55	18,250	546	275,500	2,408	504,750	62,937	43,772,750	60,355	37,779,250
1899..	4,962	1,753,250	962	937,250	79	34,250	565	329,500	2,337	517,250	51,539	35,948,500	50,769	31,870,250
1900..	4,003	1,674,250	1,007	989,250	76	31,250	504	304,500	2,746	553,500	37,004	25,874,000	54,859	34,437,750
1901..	4,536	1,427,250	884	783,250	91	37,250	459	264,000	2,561	701,250	48,964	30,951,000	54,415	34,157,250



Year.	Soda, Nitrate. (Chile Saltpeter.)		Stassfurt Salts.	Stone. Rough or Simply Hewn.		Limestone. Lime.		Grindstones, Polishing and Whetstones.		Sulphur.	
1897...	465,498	$16,875,000	6	.....	852,825	$4,275,000	225,715	$1,200,000	1,450	$113,750	25,376	$825,000
1898...	425,054	15,409,250	17	.....	931,826	4,295,000	242,797	1,333,250	1,967	147,250	30,269	756,750
1899...	536,944	19,431,000	142	$1,250	1,021,755	5,199,750	229,912	894,750	2,192	208,500	31,196	702,000
1900...	484,544	19,381,750	130	750	1,072,433	6,478,750	272,324	1,021,250	2,236	208,750	40,049	915,500
1901...	529,598	22,506,750	155	750	926,994	4,736,750	261,659	915,750	(c)	.....	32,750	818,750

Year.	Tin. Crude.		Tin. Manufactures.		Zinc. Crude.		Zinc. Drawn and Rolled.		Zinc. Manufactures.		Zinc. Ore.		Zinc-White, Zinc-Gray, and Lithophone.	
1897..	12,395	$3,875,000	75	$75,000	19,734	$1,850,000	130	$325,000	146	$75,000	24,735	$400,000	3,528	$325,000
1898..	14,023	5,201,000	82	98,500	24,116	2,413,500	53	5,750	128	77,250	48,050	901,100	3,653	365,250
1899..	12,258	7,566,250	88	115,000	23,691	2,916,500	95	12,500	126	79,000	57,980	1,454,000	4,226	465,250
1900..	12,454	6,375,250	115	159,500	24,263	2,374,250	145	15,750	132	82,500	68,982	1,456,000	4,884	512,250
1901..	12,910	7,580,000	93	121,250	21,250	1,899,250	306	30,500	126	77,250	75,583	1,358,500	3,673	339,000

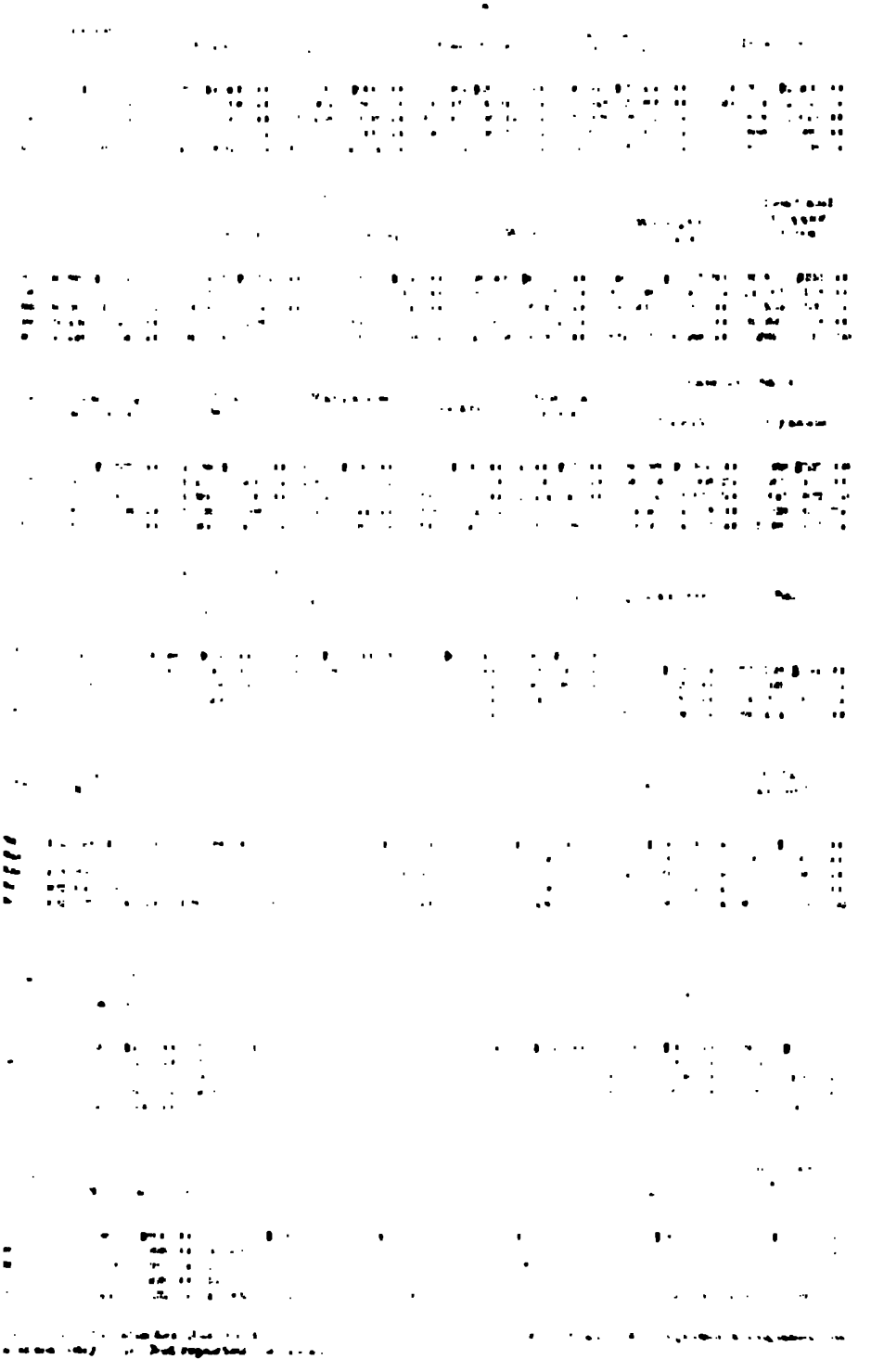
MINERAL EXPORTS OF GERMANY. (a) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products. Roofing Tile, and Building Stone.		Clay Products. Porcelain.	
1897.....	2,727	$75,000	1,899	$1,950,000	2,623	$100,000	524,557	$4,500,000	99,128	$925,000	21,687	$3,750,000
1898.....	(c)	.....	2,045	2,137,500	4,083	173,500	551,744	5,004,000	122,285	1,160,500	21,644	3,408,500
1899.....	(c)	.....	2,312	2,588,250	1,553	77,750	580,255	5,164,500	152,819	1,453,750	23,110	9,015,75
1900.....	(c)	.....	2,398	2,690,250	2,431	127,500	600,386	6,359,750	148,668	1,533,250	26,642	10,727,750
1901.....	(c)	.....	2,270	2,465,250	9,842	541,250	560,612	4,608,500	100,801	1,064,500	27,649	12,870,250

Year.	Clay Products. Con. Kaolin, Feldspar and Fire Clay.		Coal.		Coal, Lignite.		Coke.	
1897.....	121,535	$475,000	12,389,907	$33,375,000	19,112	$25,000	2,161,886	$9,150,000
1898.....	129,092	651,250	13,989,223	39,925,500	22,155	36,500	2,133,179	10,197,750
1899.....	143,406	729,000	13,943,174	45,040,250	20,925	36,500	2,137,985	11,490,50
1900.....	159,855	941,000	15,275,805	54,234,500	52,705	105,500	2,229,188	13,942,250
1901.....	128,174	794,500	15,266,267	52,420,500	21,718	43,500	2,0e6,981	13,189,250

Year.	Copper. Crude.		Copper. Bars and Sheets, Unplated.		Copper. Scrap and Coin.		Copper and Brass Manufactures. Fine.		Copper and Brass Manufactures. Wire.		Copper and Brass Manufactures. Cartridge Cases, Coarse Wares, etc.	
1897.....	7,183	$1,895,000	5,718	$1,895,000	2,164	$525,000	5,583	$4,625,000	6,176	$2,025,000	5,409	$3,350,000
1898.....	6,972	1,885,500	5,309	1,798,500	3,636	892,750	6,472	5,471,500	5,980	2,080,500	6,278	3,776,750
1899.....	7,061	2,598,750	4,871	2,118,500	5,217	1,804,750	7,561	6,986,500	7,579	3,369,750	5,846	3,951,250
1900.....	5,505	2,090,750	5,278	2,388,250	5,455	1,998,500	8,898	8,294,500	9,605	4,308,000	4,906	3,333,750
1901.....	5,097	1,765,750	4,952	2,072,000	5,181	1,597,250	7,859	7,361,750	7,833	3,289,000	4,908	3,323,250

Year.	Glass Manufactures, All Kinds.		Gold. Bullion. Kg.		Gold. Coin. Kg.		Gold and Silver Manufactures. Kg.		Gold, Silver, and Platinum Ores.		Graphite.	
1897...	105,702	$9,050,000	32,312	$22,525,000	11,385	$7,150,000	101,429	$9,975,000	53	$25,000	2,622	$127,500
1898...	102,615	7,757,250	4,851	3,381,250	82,902	52,061,000	98,939	10,286,000	18	84,750	2,986	171,500
1899...	111,037	8,450,250	4,850	3,387,750	48,594	30,548,500	107,021	12,181,250	5	10,250	2,708	177,500
1900...	124,501	9,366,000	5,587	3,902,500	39,072	24,562,500	111,117	18,370,750	20	4,500	2,068	78,250
1901...	112,291	9,187,500	8,661	6,049,750	10,893	6,848,000	98,564	15,213,750	5	8,500	(c)	.....



MINERAL IMPORTS AND EXPORTS OF GERMANY FOR THE YEAR 1902. (IN METRIC TONS.)

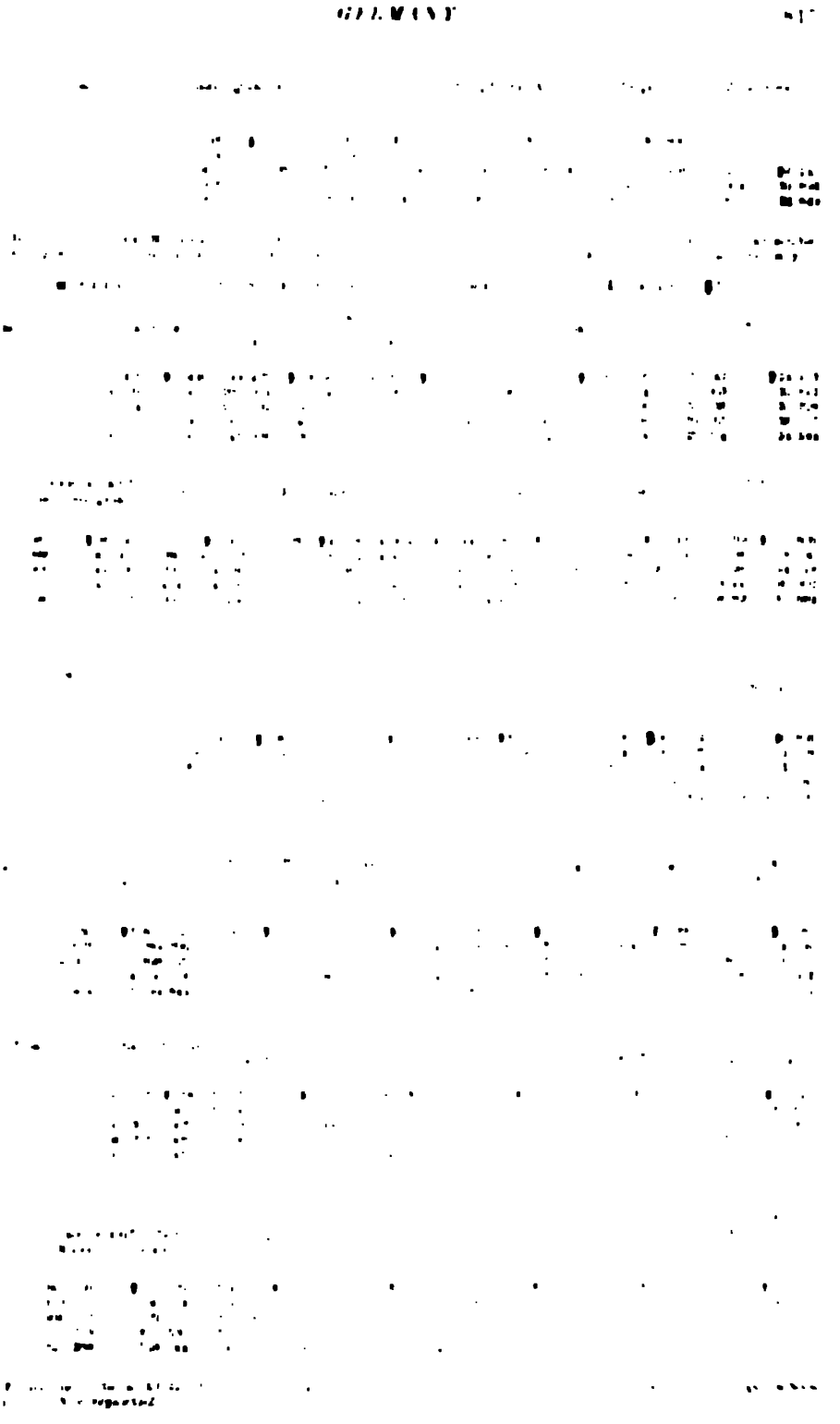
The following figures are taken from *Chemiker Zeitung*, of Feb. 4, 1903, and while probably from official sources, are subject to correction.

Substances.	Imports.	Exports.	Substances.	Imports.	Exports.
Alum, and aluminate of sodium and alumina, including hydrate	188	34,066	Lead and copper ores	94,447	19,055
Aluminum	1,100	410	Lead	39,906	23,100
Ammonium salts	1,964	3,351	Lead, white	357	19,070
Ammonium sulphate	42,252	5,744	Lignite	7,892,010	21,760
Ammoniacal liquor	10,267	15,857	Litharge	169	4,070
Antimony	1,495	105	Magnesium, artificial carbonate	43	316
Antimony and arsenic ore	1,231	410	Magnesium, natural carbonate	12,237	2,955
Arsenic	.....	46	Manganese ore	204,647	4,208
Arsenic, white	347	1,222	Manganese preparations	417	892
Arsenical compounds	42	812	Mineral oil for use in the arts	5,782	603
Asbestos and asbestic mastic	3,417	709	Nickel	1,456	699
Asphalt, pitch, and wood cement	69,536	40,595	Nitric acid	1,374	1,650
Barium chloride	2,135	4,445	Ozokerite, crude	1,595	672
Barium salts, N. E. S.	56	3,913	Ozokerite, refined	77	1,856
Baryta-white	1	2,922	Petroleum, crude	6,721	.....
Barytes	2,198	55,763	Petroleum, distilled	5,847	4,006
Bauxite, crude	26,698	32	Petroleum, refined	986,562	875
Borax and boric acid	2,057	2,836	Phosphorus	350	260
Brass and tombac	1,192	5,3 2	Pitch, except asphalt	24,266	5,102
Bromide of potash and other bromine preparations	18	357	Potash	2,112	14,041
Bromine	.....	153	Potash, caustic	42	13,804
Calcium chloride	203	1,346	Potassium and sodium chlorate	1,913	758
Carbon bisulphide	26	193	Potassium chloride	261	106,925
Carbonic acid	625	3,368	Potassium chromate	445	995
Cement	52,018	699,459	Potassium cyanide	3	3,257
Chloride of lime	51	29,694	Potassium iodide and other iodine preparations	10	152
Chloride of magnesium	35	14,757	Potassium sulphate	266	40,787
Chrome alum	22	1,758	Quicksilver	648	100
Chrome ore	10,152	846	Salt	26,404	393,324
Coal	6,425,658	16,101,141	Saltpeter, Chile	461,024	14,761
Coal-tar oil, light	7,591	2,222	Saltpeter, potassium	1,889	9,734
Coal-tar oil, heavy	6,800	5,704	Soda, calcined	121	33,109
Cobalt and nickel ore	15,551	3	Soda, caustic	106	5,650
Coke	362,498	2,182,383	Soda, crystallized	61	2,449
Copper, crude	76,050	46.78	Soda chromate	197	1,731
Copper, in bars and sheets	133	2,425	Soda, carbonate	108	954
Copper alloys, in bars, sheets, etc.	407	3,763	Sodium and potassium sulphide	397	4,565
Cinnabar	12	192	Stone, refractory, from clay	23,018	91,007
Cryolite	1,332	486	Strontia minerals	34,035	702
Explosives	68	3,319	Strontia preparations	74	546
Fluorspar	31	14,177	Sulphur	32,798	576
Gold, silver, and platinum ores	6,584	.....	Sulphuric acid	22,205	47,966
Gold preparations and salts	.....	6	Superphosphate	109,374	77,518
Graphite, crude	19,392	1,691	Thomas slag, ground	103,107	102,092
Gunpowder	79	1,230	Tin	13,760	2,271
Gypsum	8,177	42,859	Tin salts	70	301
Hydrochloric acid	2,449	12,307	Ultramarine	83	4,226
Iodine	220	24	Vitriol, all kinds	3,308	6,055
Iron, crude, all kinds	174,990	516,105	Waterglass	250	6,023
Iron, wrought, in bars	24,579	361,216	Witherite	2,842	273
Iron alum and iron mordant	417	369	Zinc, ingot	25,936	70,939
Iron ores	3,957,408	2,868,008	Zinc ores	61,407	46,967
Iron oxide, red	2,057	1,755	Zinc, sheet	134	17,054
Kaolin, feldspar, and refractory clay	229,556	136,928	Zinc white, zinc gray, and zinc sulphate	3,954	19,773

MINERAL PRODUCTION OF BADEN. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alumina Sulphate.		Barytes.		Coal.		Fire Clay.		Gypsum.		Iron. Cast, Foundry.	
1897	1,824	$27,134	400	$300	4,752	$11,880	11,450	$6,654	40,709	$26,972	36,235	$1,873,282
1898	2,051	30,505	1,100	825	4,133	10,333	5,112	3,529	28,037	16,137	39,988	1,853,282
1899	2,153	29,610	2,430	2,126	4,700	13,000	4,775	3,475	29,419	18,871	53,608	2,769,252
1900	2,286	33,725	2,970	2,745	4,930	15,406	3,096	2,650	26,381	15,429	50,102	2,765,058
1901	2,200	33,900	e3,991	3,682	3,650	10,174	2,530	2,864	28,183	17,348	40,100	2,029,292

Year.	Iron.—*Continued.* Ingot.		Wrought.		Lead and Copper Ores.		Limestone. (*d*)		Salt.	
1897	3,875	$147,718	1,167	$58,401	(*b*)	.....	137,670	$19,502	31,445	$136,988
1898	3,875	147,718	1,167	58,401	(*b*)	.....	164,979	26,104	31,445	136,988
1899	3,880	171,863	1,402	63,117	(*b*)	.....	201,015	31,624	31,197	116,737
1900	3,582	184,909	1,364	85,217	67	*b*$3,308	221,097	36,312	32,099	192,594
1901	8,739	376,800	1,158	68,941	†369	15,025	168,945	27,843	32,835	243,989



MINERAL PRODUCTION OF PRUSSIA (a) (METRIC TONS; 4 marks = $1.)

Year.	Alum Shale		Antimony and Alloys.		Arsenic Products.		Arsenic Ore		Asphalt	
1897	129	$193	1,552	$152,744	1,024	$143,775	[illegible]	[illegible]	[illegible]	[illegible]
1898	107	161	2,012	251,642	1,024	121,816	[illegible]	[illegible]	[illegible]	[illegible]
1899	145	217	2,003	332,965	1,409	128,543	[illegible]	[illegible]	[illegible]	[illegible]
1900	103	154	3,102	3 6,137	1,563	138,549	[illegible]	[illegible]	[illegible]	[illegible]
1901	611	718	2,404	295,164	1,446	109,430	[illegible]	[illegible]	[illegible]	[illegible]

Year.	Bauxite.		Cadmium. Kg.	Coal.		Coal. (Lignite.)		Cobalt Ore		Cobalt Products.	
1897	187	$9,663	15,531	$44,157	84,253,393	$145,665,149	24,222,911	$18,334,245	121	$6,256	51	$166,65
1898	216	10,162	14,943	31,162	89,593,528	160,467,355	26,035,814	14,781,696	84	1,710	44	141,62
1899	171	8,337	13,606	21,336	94,740,869	179,284,432	28,414,598	15,876,512	17	950	46	149,75
1900	217	10,261	13,533	20,579	101,995,158	219,502,770	34,907,542	20,064,519	4	160	69	282,67
1901	164	7,196	13,144	20,459	101,293,807	231,139,057	37,491,412	22,606,563	35	2,100	65	228,69

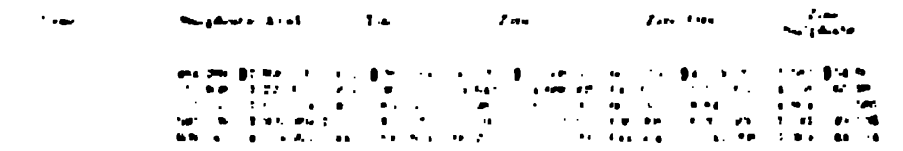
Year.	Copper.		Copper and Iron Sulphate		Copper Ore.		Copper Matte		Copper Sulphate.		Epsom Salt.	
1897	25,907	$6,606,664	225	$6,548	660,339	$4,095,679	274	$13,157	2,099	$225,877	2,248	$4,92
1898	27,216	7,277,295	120	4,126	691,866	4,867,052	62	2,170	1,701	130,109	2,061	4,49
1899	30,502	11,336,549	154	6,019	722,894	5,137,918	95	4,045	1,586	142,124	1,763	3,67
1900	27,974	10,655,905	113	4,367	736,586	5,843,469	4,103	576,222	2,556	291,288	1,511	3,11
1901	28,422	10,541,997	78	3,049	765,241	5,975,496	210	34,334	1,951	213,276	1,958	3,59

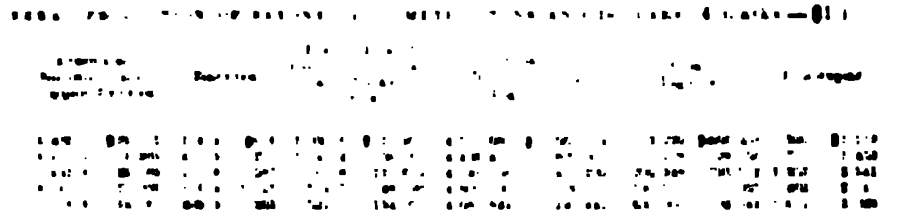
Year.	Gold - Kg.		Iron.		Iron Ore.		Iron Sulphate.		Lead.	
1897	1,097·1	$756,184	4,902,059	$64,780,081	4,183,536	$8,432,766	9,064	$33,037	108,880	$6,556,528
1898	1,036·8	719,787	5,176,943	69,822,640	4,020,809	8,135,065	9,144	31,007	119,346	7,692,050
1899	1,016·4	708,524	5,644,614	83,302,190	4,295,575	8,780,812	10,186	31,732	116,905	8,433,993
1900	1,499·9	1,045,080	5,781,803	95,586,944	4,298,069	9,421,502	10,233	35,762	112,738	9,426,952
1901	1,157·5	806,408	5,315,628	88,442,417	3,831,670	9,082,051	10,239	35,269	113,939	7,455,639

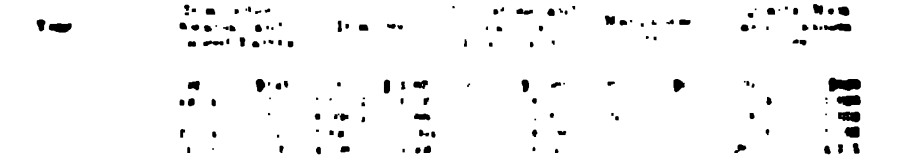
Year.	Lead Ore.		Litharge.		Manganese and Alloys.		Manganese Ore		Nickel.		Nickel Ore.		Nickel Sulphate.	
1897	183,158	$8,129,880	1,000	$127,787	113	$58,000	45,254	$103,137	898	$760,562	204	$1,580	167	$42,327
1898	183,637	8,218,107	2,300	160,554	99	51,250	42,232	96,691	1,108	706,198	79	693	127	21,690
1899	138,049	8,476,074	2,482	191,601	143	81,250	60,379	158,946	1,115	705,125	91	1,067	123	21,546
1900	183,493	4,457,035	2,907	207,469	174	87,250	58,016	165,203	1,376	970,224	3,896	19,488	115	20,286
1901	189,985	3,487,807	2,885	206,404	121	60,100	55,866	163,545	1,660	1,220,891	9,922	49,378	121	21,206

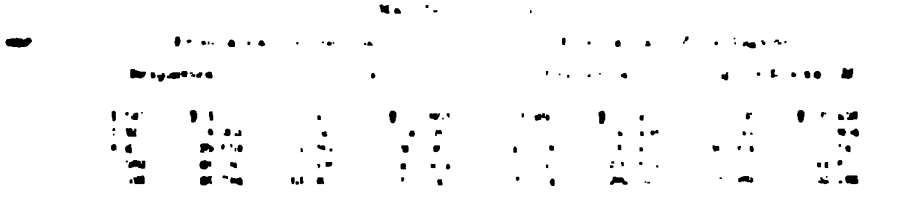
Year.	Ocher and other Mineral Paints.		Petroleum.		Potassium Salts.				Pyrites.		Quicksilver. Kg.	
					Kainite.		Other Potash Salts.					
1897	2,400	$48,750	2,600	$73,038	716,348	$2,529,349	640,236	$1,898,647	121,766	$309,201	4,867	$4,684
1898	2,376	51,000	2,545	70,513	744,240	2,560,761	718,957	2,161,101	128,077	230,411	4,717	4,282
1899	2,770	57,082	3,405	91,714	744,057	2,559,169	941,055	2,622,148	134,564	234,596	2,611	3,354
1900	2,850	60,000	27,731	608,832	857,271	3,030,771	1,264,998	3,598,825	150,186	260,233	1,771	2,250
1901	2,800	62,500	24,098	461,018	1,068,337	4,010,879	1,131,708	3,597,630	148,457	263,788	1,713	2,175

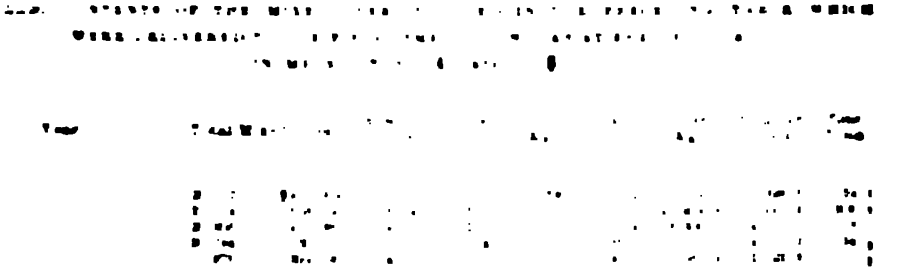
Year.	Salt.				Selenium.	Silver—Kg.		Silver and Gold Ore.		Sulphur.	
	Common.		Rock.								
1897	274,888	$1,643,473	310,735	$358,697	25	$402	289,960	$5,907,572	6	$4,901	2,091	$42,480
1898	296,051	1,640,914	329,959	377,162	65	1,015	291,969	5,776,802	43	2,966	1,735	38,306
1899	288,588	1,645,182	331,943	391,406	46	725	293,868	5,983,217	7	30,347	1,419	30,000
1900	287,005	1,764,750	354,608	417,750	6	94	266,577	5,547,499	1	7,081	1,207	25,530
1901	280,869	1,877,762	353,357	418,575	Nil.	.....	248,286	4,954,635	6	9,950	772	15,333











PRODUCTS SOLD BY THE FISCAL SMELTING WORKS AT FREIBERG AND THE COBALT WORKS AT SCHNEEBERG, GERMANY. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Arsenical Products. (*d*)		Bismuth. Kg.		Cobalt Products.		Copper Sulphate.		Fine Gold. Kg.		Lead. Products. (*e*)		Lead. Sheet	
1897....	1,053	$127,122	1,624	$3,901	628	$581,559	1,878	$162,881	899	$619,851	5,421	$332,652	634	$41,486
1898....	1,053	131,710	1,375	3,774	631	620,217	1,777	146,164	851	579,519	7,456	495,096	647	45,710
1899....	953	128,572	1,300	3,443	645	705,347	2,550	228,963	832	581,001	6,422	463,557	1,012	77,254
1900....	829	124,587	1,675	4,424	596	708,199	1,545	184,497	809	628,244	4,633	399,906	514	46,813
1901....	1,109	148,162	1,656	6,161	466	669,479	2,405	208,646	926	646,612	4,791	338,814	335	41,235

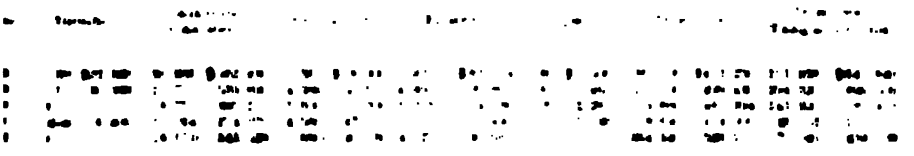
Year.	Lead.—*Continued.* Shot.		Other Manufactures of. (*f*)		Nickel, Speiss.		Fine Silver—Kg.		Sulphuric Acid. (*g*)		Other Chemicals. (*h*)	
1897....	142	$9,950	224	$15,771	75	$4,166	72,892	$1,465,076	10,788	$73,450	472	$5,672
1898....	127	9,515	218	16,746	56	3,409	79,555	1,593,071	11,574	102,639	545	5,089
1899....	208	16,851	301	26,759	54	3,469	85,741	1,743,021	11,844	113,776	565	5,485
1900....	153	15,202	159	15,419	30	1,795	83,896	1,751,600	11,965	119,565	519	5,418
1901....	160	12,480	156	12,168	33	1,788	76,474	1,545,310	16,556	126,804	413	4,004

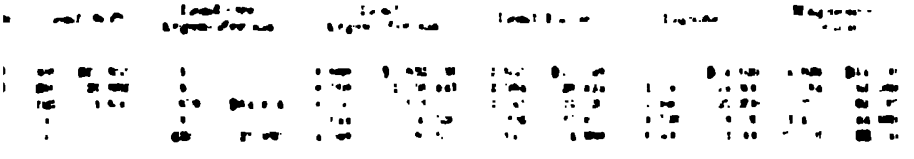
Year.	Zinc and Zinc Dust.		Clay and Chamotte Manufactures. (*i*)	Total Value.
1897....	120	$10,483	$16,855	$2,907,602
1898....	227	21,978	18,478	3,774,873
1899....	169	21,729	16,402	4,145,102
1900....	29	3,521	14,375	4,083,565
1901....	59	5,486	14,790	3,861,899

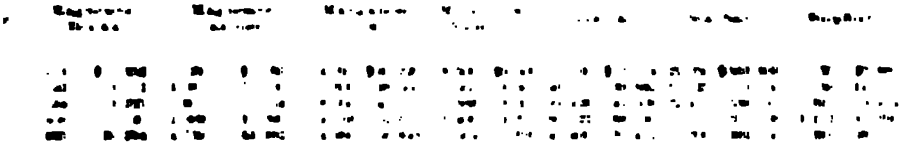
(*a*) From *Jahrbücher für das Berg- und Hüttenwesen im Königreiche Sachsen.* (*b*) Including arsenic powder, slags, washing-sand, granular ore, refuse stones and chippings. (*c*) Including silver-bearing lead, copper, arsenic, zinc and sulphur ores. (*d*) Including arsenious acid, red, yellow and white glass, and metallic arsenic. (*e*) Including assay lead, soft lead, antimonial lead, litharge, lead fume and tin-lead. (*f*) Including lead pipes, lead wire and various lead apparatus. (*g*) Including sulphuric acid of all kinds. (*h*) Including copperas and glauber salt. (*i*) Including tiles, plates, figured stone, muffles, clay and graphite crucibles, and assaying utensils. (*j*) Not reported.

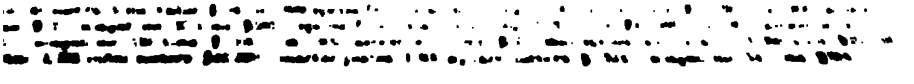
GREECE

The statistics of mineral products in Greece are summarized in the following tables:









INDIA.

THE official statistics of mineral production in British India, and the imports and exports, are summarized in the subjoined tables:

MINERAL PRODUCTION OF INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees = $1.)

Year.	Alum.		Asbestos. Kg.		Borax.		Clay.	Coal.		Copper Ore.		Fullers Earth.	
1897	509	(*b*)	254	$10	280	$23,622	(*c*)	4,128,330	$3,116,647	33	$69	318	$15
1898	762	$15,750	254	10	184	15,456	(*c*)	4,678,640	3,576,167	(*b*)	.....	(*b*)	.....
1899	4	117	51	2	(*b*)	.....	$508,862	5,016,055	3,884,968	52	256	(*b*)	.....
1900	...	.....	51	2	(*b*)	.....	1,088,716	6,216,883	5,096,555	77	61	(*b*)	.....
1901	...	.....	...	.....	(*b*)	.....	.....	6,958,837	4,962,645	25	.....	.....	.....

Year.	Gold—Kg.		Granite. (c)		Graphite.		Gypsum.		Iron Ore.		Laterite.	
1897	12,100	$5,581,439	633,302	*d*$120,381	61	.....	8,187	$1,082	44,009	$38,075	5,399,794	*c*$4,074
1898	12,773	6,031,800	806,131	*d*123,815	22	.....	8,390	1,160	50,559	46,903	6,173,667	(*c*)
1899	14,214	6,461,560	811,019	*d*136,444	1,548	*c*$5,895	6,546	592	61,697	46,843	6,010,588	*c*$3,888
1900	15,946	7,004,266	368,759	*d* 72,020	1,859	9,104	4,415	424	64,085	41,481	565,351	147,259
1901	16,589	7,240,265	.....	.....	2,771	.....	.....	.....	58,725	.....	.....	.....

Year.	Limestone.		Manganese Ore.		Mica.		Petroleum—*Gallons.*		Rubies.
1897	1,861,309	$195,673	74,862	$147,500	708	$49,751	19,128,888	$565,943	$200,613
1898	1,924,577	(*c*)	61,469	120,900	271	56,965	18,972,368	254,580	217,313
1899	2,188,985	371,791	88,520	65,344	630	227,378	32,984,007	471,315	340,998
1900	1,201,875	190,102	*c*182,767	425,085	931	221,417	37,739,211	557,831	364,974
1901	8,504	.....	164,650	359,464	1,018	248,973	50,075,117	706,283	284,417

Year.	Salt.		Saltpeter.		Sandstone.	Slate. (c)		Soapstone. (c)		Tin Ore. (c)		Trap Rock. (c)	
1897	937,932	$1,219,074	12,819	$440,630	956,532	*c*$48,328	26,589	$10,102	1,008	$3,915	62	$9,888	140,764	$19,689
1898	1,043,824	1,485,702	11,702	402,560	*c*1,174,454	(*c*)	26,954	10,755	1,839	(*b*)	40	9,572	128,772	(*c*)
1899	977,240	1,324,748	11,397	408,660	1,070,799	134,909	26,372	13,359	735	5,111	50	17,987	358,871	53,015
1900	1,021,426	1,146,308	11,709	407,414	400,543	107,662	7,341	6,993	2,339	7,507	106	32,102	756,221	33,488
1901	1,130,187	1,405,682	12,751	.....	.....	.....	4,269	.....	.....	.....	71	29,149	.....	.....

(*a*) From the *Review of the Mineral Production in India*; and the *Annual General Report upon the Mineral Industry of the United Kingdom of Great Britain*. (*b*) Not stated in the reports. (*c*) Incomplete. (*d*) Represents only a part of the product, about one-half in 1896, 1897, 1898, 1899 and 1900. (*e*) Exported.

ITALY.

THE official statistics of mineral and metal production in Italy, together with the imports and exports as reported in the official statistics of the Kingdom, are summarized in the following tables:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (a) (IN METRIC TONS AND DOLLARS; 5 lire — $1.)

Year.	Alum.		Aluminum. Sulphate.		Alunite.		Antimony.		Antimony Ore.		Asphalt, Mastic and Bitumen.	
1897.....	1,030	$21,180	2,310	$40,160	6,500	$6,500	404	$57,072	2,150	$34,864	18,644	$89,125
1898.....	1,165	25,060	2,915	54,560	7,000	7,000	380	62,550	1,931	43,822	17,813	111,611
1899.....	945	22,350	2,330	43,287	5,800	5,800	581	87,900	3,791	44,862	41,732	248,084
1900.....	1,007	27,131	2,403	46,467	5,200	7,280	1,174	154,360	7,609	72,468	33,127	201,863
1901.....	1,075	23,815	2,260	37,830	4,900	11,760	1,721	195,550	8,818	68,513	31,814	177,741

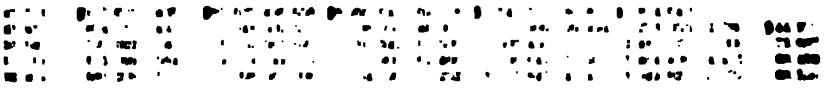
Year.	Asphaltic Rock.		Barytes.		Borax, Refined.		Boric Acid.				Coal. (b)	
							Crude.		Refined.			
1897.....	55,339	$189,655	(c)	.....	990	$88,160	2,704	$173,056	260	$31,200	314,222	$467,111
1898.....	93,750	265,645	12,400	$74,400	702	50,558	2,650	163,600	166	16,590	341,327	495,925
1899.....	81,987	230,589	12,545	87,653	709	51,084	2,674	171,136	129	11,619	389,534	551,844
1900.....	101,738	292,287	14,003	98,010	858	68,656	2,491	169,429	283	28,350	479,696	708,471
1901.....	104,111	261,761	13,245	60,470	544	46,775	2,558	194,408	347	39,512	425,614	687,313

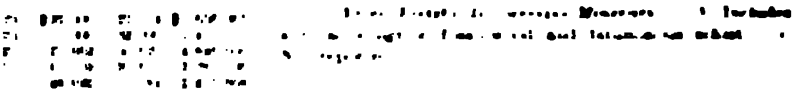
Year.	Coal. (Briquettes.)		Coke.		Copper.		Copper Ore.		Gold—Kg.		Gold Ore.	
1897.....	549,050	$2,768,350	430,617	$2,669,285	2,980	$749,954	93,377	$431,229	316·0	$218,862	10,723	$178,010
1898.....	594,500	3,373,900	469,228	2,943,821	3,230	878,509	95,128	426,299	187·9	131,818	9,549	148,896
1899.....	566,000	3,262,000	485,951	3,102,354	3,032	1,164,697	94,764	687,772	113·5	79,095	11,859	91,416
1900.....	703,740	4,750,360	487,831	3,605,303	2,797	1,096,424	95,644	631,808	57·5	39,987	5,840	53,357
1901.....	754,800	5,082,890	490,803	3,516,907	3,097	1,252,427	107,750	680,970	4·1	2,852	890	8,120

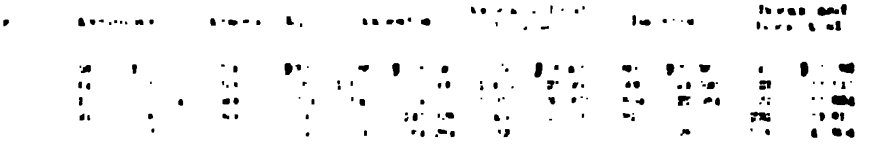
Year.	Graphite.		Iron.									
			Ore.		Bar, Sheet, Pipe, Wire, etc.		Pig.		Sheet, Tinned.		Steel.	
1897.....	5,650	$11,300	200,709	$572,102	149,944	$7,176,951	8,393	$181,763	6,500	$546,000	63,940	$4,156,850
1898.....	6,435	17,423	190,110	549,248	167,499	8,173,105	12,327	259,897	7,200	660,000	87,467	5,417,086
1899.....	9,990	55,944	236,549	706,823	197,730	10,961,105	19,218	521,428	8,000	960,000	108,501	6,759,501
1900.....	9,720	55,720	247,278	917,104	190,518	10,312,290	23,990	625,834	10,000	1,200,000	115,887	6,865,153
1901.....	10,313	59,211	232,299	734,545	180,729	9,267,228	15,819	392,184	7,550	675,000	123,310	6,542,181

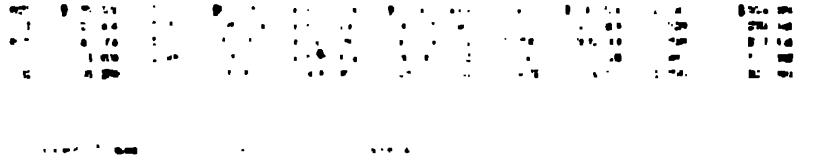
Year.	Lead.		Lead Ore.		Manganese Ore.		Manganiferous Iron Ore.		Marble.		Petroleum.		Petroleum, Benzine, etc.	
1897..	22,407	$1,462,909	36,200	$1,008,525	1,634	$15,008	21,262	$84,019	236,958	(c)	1,932	$98,456	3,392	$279,538
1898..	24,543	1,646,865	33,930	1,044,248	3,002	18,707	11,150	26,760	271,725	$2,109,440	2,015	117,826	5,040	346,821
1899..	20,543	1,580,423	31,046	1,122,161	4,356	22,432	29,874	77,149	318,744	2,438,624	2,242	118,812	5,384	420,710
1900..	23,763	2,088,469	35,103	1,447,793	6,014	30,995	26,800	67,000	310,336	2,409,410	1,683	98,854	6,077	526,255
1901..	25,796	1,805,027	43,449	1,820,372	2,181	16,634	24,290	60,239	334,146	2,635,821	2,246	134,213	4,211	416,607

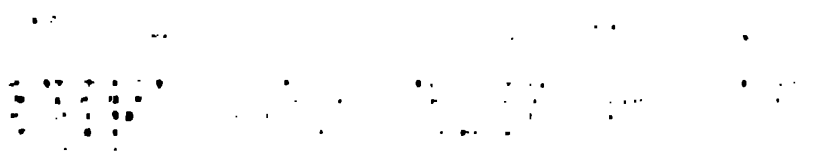
Year.	Pumice.		Pyrites. (Cupriferous in part.)		Quicksilv'r.		Quicksilver Ore.		Salt.					
									Brine.		Rock.		Sea.	
1897..	(c)	.....	58,320	$156,028	192	$192,000	20,659	$157,782	11,725	$63,100	19,801	$54,404	429,253	$885,637
1898..	2,766	$41,678	67,191	165,610	173	173,000	19,301	132,223	11,546	59,568	18,199	61,147	451,426	710,501
1899..	7,300	141,620	76,538	198,859	225	246,000	29,322	191,544	11,021	63,950	17,821	60,468	363,826	514,074
1900..	7,000	154,000	71,616	296,055	260	312,000	33,930	225,476	10,890	73,340	18,331	55,277	338,634	473,827
1901..	8,300	156,560	80,376	353,497	278	361,400	38,614	300,920	10,890	61,689	23,054	70,097	401,443	537,196











Year.	Lead. Ore. (c)		Lead. Metal and Alloys in Pigs.		Lead. Manufactures.		Lead Oxide and Carbonate.		Mineral Paints.		Nickel Alloys and Manufactures.	
1898	10,947	$503,562	1,431	$100,142	435	$75,950	647	$54,314	692	$16,606	257·7	$345,738
1899	7,476	373,800	3,990	319,232	249	51,304	662	60,859	958	23,004	250·0	235,536
1900	9,134	456,700	3,248	296,727	233	53,701	557	53,705	958	22,997	231·9	359,753
1901	9,063	380,646	2,926	187,277	268	52,921	815	70,565	865	20,748	476·3	565,501
1902	1,680	63,840	7,563	423,550	288	53,232	846	69,102	670	16,075	561·1	604,908

Year.	Petroleum.		Phosphate Rock.		Potash, Ammonia and Caustic Soda.		Potassium Sulphate.		Precious Stones, Manufactures. Kg.	
1898	70,654	$2,402,253	65,126	$781,500	11,047	$498,398	928	$50,101	319·6	$1,629,008
1899	71,391	2,998,400	116,283	1,395,396	12,370	533,413	1,297	75,214	350·1	1,323,317
1900	73,089	3,215,903	140,281	1,683,372	14,077	684,169	1,670	98,554	423·0	1,901,264
1901	69,298	2,910,503	142,108	1,563,199	14,693	814,042	1,411	79,038	193·5	2,967,041
1902	68,781	2,751,240	150,341	1,593,410	17,617	922,747	1,566	87,674	406·8	3,895,494

Year.	Salt.		Silver. Coin—Kg.		Silver. Unrefined in Bars—Kg.		Silver. Manufactures. Kg.		Quicksilver.		Slag.	
1898	26,666	$96,070	8,241	$329,640	991	$17,838	5,673	$86,594	39	$37,440	51,139	$563,197
1899	(b)	.....	20,605	824,200	1,782	32,789	4,881	80,005	62	68,420	56,549	678,592
1900	3,367	12,121	29,291	1,171,640	2,678	50,346	4,358	66,901	49	56,800	32,254	387,050
1901	8,719	31,988	35,089	1,403,560	4,391	79,058	4,213	60,416	36	40,470	7,812	8,774
1902	2,274	7,732	28,662	1,146,480	8,768	140,288	3,455	46,056	57	61,020	5,634	5,634

Year.	Sodium Salts. Carbonate.		Sodium Salts. Nitrate. (Crude.)		Sodium Salts. Refined, and Potassium Nitrate.		Tin. Bars.		Tin. Manufactures.	
1898	20,845	$458,588	19,961	$818,409	702	$48,478	1,722	$688,680	109	$50,341
1899	22,654	498,388	22,385	940,170	671	56,659	1,240	842,996	96	63,360
1900	23,215	510,734	27,706	1,191,345	511	30,812	1,648	1,183,740	56	39,104
1901	21,956	548,892	40,498	1,700,920	815	27,518	1,858	1,115,100	91	61,014
1902	26,133	653,327	24,483	1,028,294	814	25,756	2,114	1,268,340	110	73,678

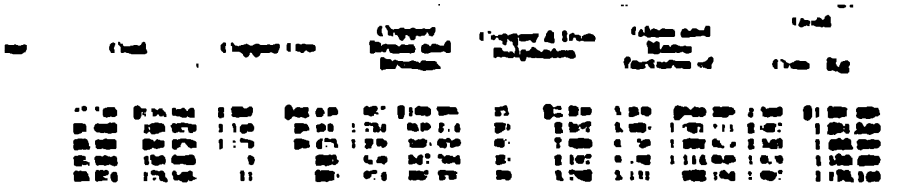
Year.	Zinc. Ore.		Zinc. Oxide.		Zinc. Pigs and Old.		Zinc. Manufactures.		Metals Not Specified. Crude.		Metals Not Specified. Manufactures.	
1898	216	$4,320	573	$63,008	2,813	$308,793	3,200	$441,066	1,612	$128,944	27	$14,416
1899	(b)	.....	804	96,468	3,498	461,776	3,221	523,130	2,726	245,331	15	7,497
1900	85	1,870	1,034	130,141	3,027	391,738	3,543	491,104	2,737	266,589	43	23,166
1901	23	460	813	97,512	3,901	351,243	4,079	476,328	2,573	238,088	24	11,904
1902	181	2,882	904	108,468	3,805	350,097	4,167	496,925	2,850	234,576	23	15,342

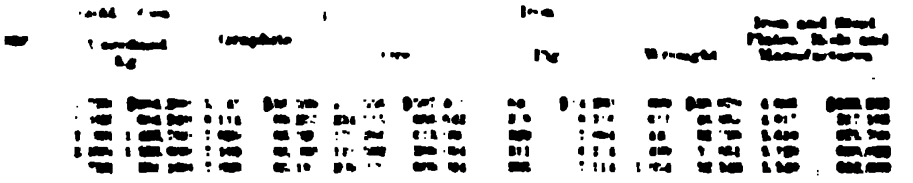
(a) From the *Movimento Commerciale del Regno d'Italia.* (b) Not reported. (c) Includes argentiferous lead ore.

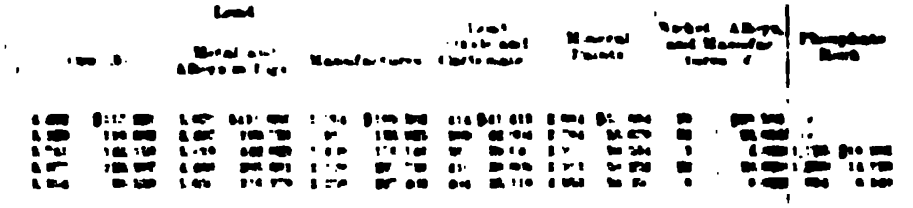
MINERAL EXPORTS OF ITALY. (a) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

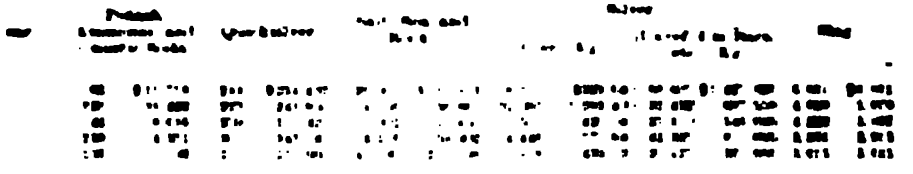
Year.	Antimony.		Asbestos.		Asphaltic Product. (Bitumen.)		Barytes.		Borax and Boric Acid.		Cement and Hydraulic Lime.	
1898	338	$64,315	208	$16,672	19,465	$311,440	70	$1,828	2,167	$143,925	5,192	$41,536
1899	240	50,402	245	19,568	26,402	422,432	45	1,165	2,872	209,783	5,462	43,696
1900	467	96,140	261	20,864	24,287	388,586	40	1,105	2,114	167,909	6,860	53,510
1901	705	130,118	302	18,102	21,856	349,689	32	756	2,190	159,224	8,463	65,628
1902	359	53,895	144	8,634	20,884	334,146	91	2,194	1,847	123,937	7,930	59,324

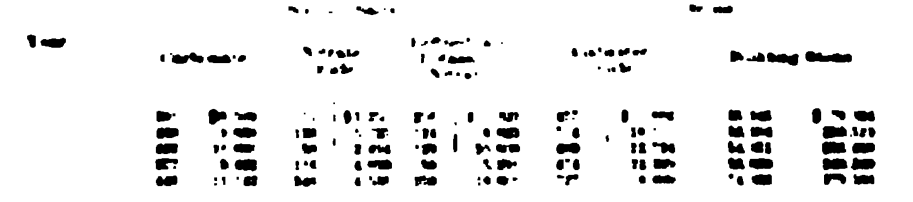
Year.	Chalk.		Clay Products. Brick, Tile, etc.		Clay Products. Kaolin.		Clay Products. Porcelain.		Clay Products. Potters' Clay and Manufactures.		Clay Products. Terra Cotta.	
1898	6,744	$40,504	125,614	$711,039	94	$752	86	$28,476	1,292	$196,600	2,751	$88,254
1899	5,386	32,316	136,402	769,182	94	658	124	39,253	1,347	238,040	2,796	102,298
1900	2,980	14,900	122,388	689,534	179	1,432	96	29,923	1,579	298,940	3,051	106,706
1901	3,428	17,140	108,057	600,351	368	2,944	266	69,079	1,958	332,770	3,325	112,817
1902	4,215	21,075	133,922	754,589	Nil.	.....	158	46,505	1,889	319,560	3,378	110,018

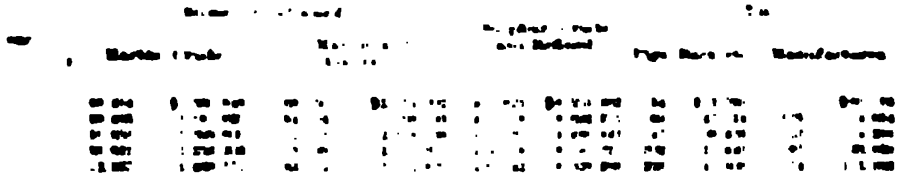


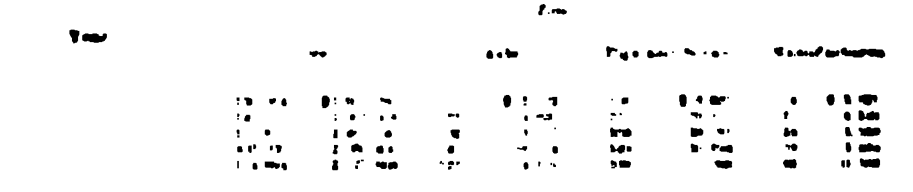


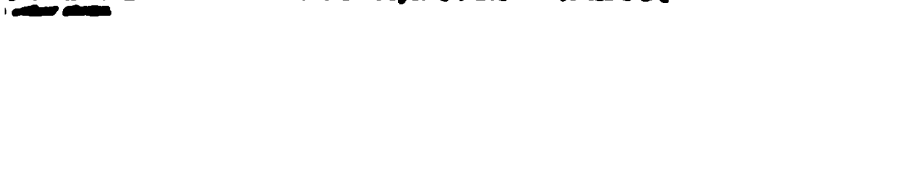












a From the Statistiche (Movimento del Regno d Italia). b Including [illegible]

JAPAN.

THE mineral production of Japan is reported in the subjoined tables.

MINERAL PRODUCTION OF MINES IN JAPAN WORKED BY THE GOVERNMENT. (*a*)

(In metric tons.)

Year	Gold. Kg.	Silver. Kg.	Copper.	Iron—Pig.	Lead.	Antimony. Ore.	Antimony. Metal	Manganese	Salt. *Hektoliters.*
1896	903·01	64,644·88	20,118·87	27,490·77	1,867·66	827·58	517·28	17,967·05	9,443,459·79
1897	1,099·84	84,887·40	20,424·07	28,089·88	773·15	348·22	824·20	15,447·51	11,144,672·77
1898	1,101·27	90,547·04	21,000·20	28,651·77	1,695·79	1,006·08	283·16	11,517·56	11,481,876·52
1899	1,078·00	56,204·00	24,817·90	28,070·95	1,891·51	713·33	229·38	11,855·70	10,482,500·78
1900	2,198·16	98,000·78	26,800·41	24,841·68	1,878·05	80·88	349·00	15,830·72	11,889,701·52

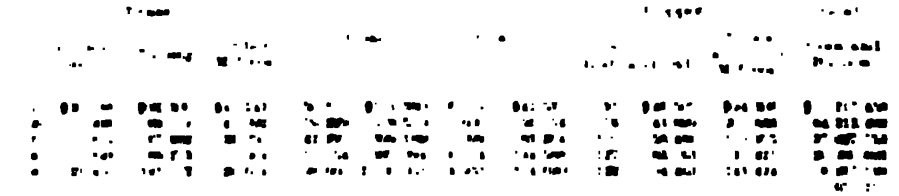
MINERAL PRODUCTION OF JAPANESE PRIVATE MINES. (*a*) (IN METRIC TONS.) (*b*)

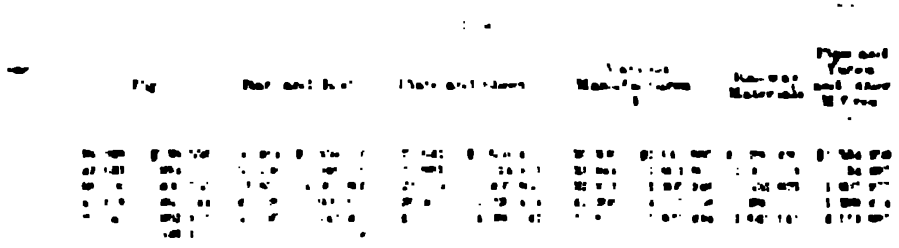
Year.	Antimony. Ore.	Antimony. Metal.	Arsenic Kg.	Coal.	Copper.	Copperas	Gold. Kg.	Graphite.	Iron.	Lead.	Manganese Ore.
1897 (*d*)	848·2	824·5	13,001·4	5,888,157	20,425	4·2	1,058·38	391	28,040	772·3	15,448
1898 (*d*)	1,000·1	283·2	7,141·0	6,606,088	21,000	20·1	1,161·27	347	23,652	1,705·5	11,517
1899 (*d*)	712·0	229·0	5,000·0	6,721,708	24,818	864·0	1,079·39	55	23,076	1,988·6	11,340
1900 (*d*)	81·0	349·0	5,000·0	7,420,457	25,304	932·0	2,130·00	94	22,712	1,857·0	15,298
1901 (*d*)	118·5	429·3	10·3	8,045,989	27,439	922·8	2,479·83	98	20,172	1,816·1	16,296

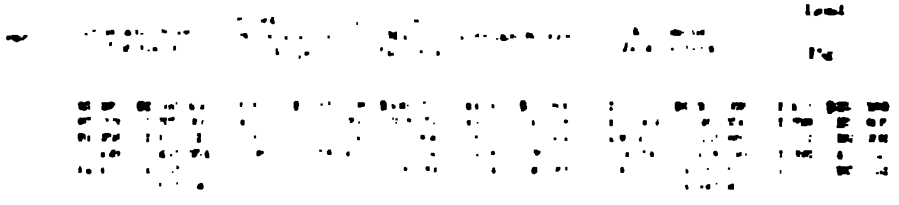
Year.	Ocher, Red.	Petroleum, Refined.	Quicksilver. Kg.	Silver. Kg.	Sulphur. Refined	Tin.
1897 (*d*)	33·7	34,743	2,682	54,387·4	18,606	47·7
1898 (*d*)	7·0	43,184	1,401	60,547·0	10,339	42·7
1899 (*d*)	28·0	(*e*) 72,478,737	(*c*)	56,308·5	10,241	18·5
1900 (*d*)	33·0	(*e*) 121,906,240	2,700	58,953·0	14,435	12·0
1901 (*d*)	82·7	147,325	7,513	54,889·2	16,577	14·1

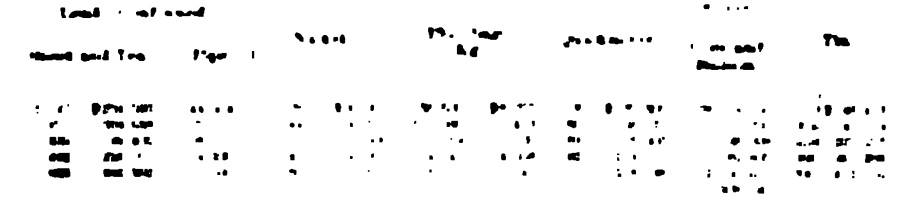
(*a*) From *Resumé Statistique de l'Empire du Japon*, Tokio, and special reports from the Japanese Government. The data contained in the table of production of the Government mines are nearly exact, but those contained in the table of private mines, being the figures furnished by the mine owners themselves, are only an approximation and considerably less than the actual figures. (*b*) In making the conversions from the Japanese units to metric tons, hektoliters and dollars, the following relations were employed: 1 kwan = .003·765 metric tons; 1 koku = 1·9839 hektoliters; 1 yen = $1; 1 kg. = 32·151 troy ounces. (*c*) Not reported. (*d*) Includes production of Government mines. (*e*) Liters of crude oil. In 1901, there were also produced 17,519 metric tons of pyrites.

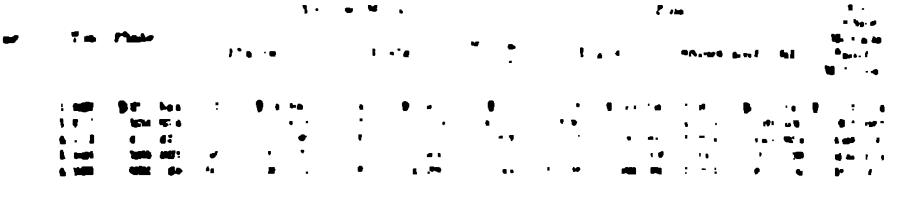
MINERAL IMPORTS OF JAPAN (IN METRIC TONS AND DOLLARS)











MINERAL EXPORTS OF JAPAN. (a) (IN METRIC TONS AND DOLLARS.)

(1 kin = 0·[illegible] metric tons; 1 yen = $1.)

Year.	Antimony.			Brass.		Bronze.			Coal.	
	Metal.		M'fac-tures.	Wire.	M'fac-tures.	Ingot.		M'fac-tures.	For Ships' Use.	
1896	684	$48,906	$104,010	222	$108,612	$35,586	54	$14,570	$180,318	568,963	$2,636,394
1897	1,577	277,549	63,331	147	72,414	66,366	27	8,373	183,022	592,051	3,229,084
1898	1,339	216,599	51,130	218	112,052	19,712	*Nil.*	.....	207,345	381,426	2,928,177
1899	1,045	205,515	58,498	148	92,705	17,362	*Nil.*	.....	220,143	473,919	3,390,135
1900	877	107,707	75,777	147	102,759	17,105	*Nil.*	.....	208,173	946,763	6,288,448

Year.	Coal—*Continued.*				Coke.		Copper.			
	Dust.		Other Kinds.				Ingot.		Old.	
1896	299,102	$980,704	1,350,458	$5,312,227	3,399	$29,114	6,756	$2,423,116	0·32	$13
1897	189,122	859,514	1,366,498	7,457,202	2,950	45,384	2,741	1,075,945	6·81	2,077
1898	(*b*)	.....	1,805,364	12,240,621	3,381	56,914	385	160,583	*Nil.*	.....
1899	(*b*)	.....	2,013,695	11,784,730	3,556	57,243	96	51,481	*Nil.*	.....
1900	(*b*)	.....	2,402,785	13,708,654	5,221	86,610	70	45,750	*Nil.*	.....

Year.	Copper—*Continued.*						Gold.	Iron Wares.
	Refined.		Slab.		Wire.	M'fac-tures.	Coin and Bullion.	
1896	6,134	$2,461,089	1,644	$594,448	72	$33,717	$135,079	$1,996,576	$105,481
1897	6,172	2,680,807	5,045	2,017,947	98	46,947	223,234	8,868,798	179,037
1898	16,069	7,106,491	144	75,481	83	46,998	182,040	46,281,343	200,595
1899	21,308	11,331,876	186	99,381	56	40,278	59,136	8,768,365	185,230
1900	20,407	12,680,184	190	137,992	79	58,490	75,829	51,761,690	247,538

Year.	Other Metal Wares.	Manganese Ore.		Silver.	Sulphur.		Other Mineral Products.	Total.
				Coin and Bullion.				
1896	$358,126	20,080	$274,434	$9,602,308	12,325	$208,588	$1,920	$27,759,986
1897	486,862	14,665	205,318	10,355,365	9,209	321,341	1,396	28,710,394
1898	287,556	9,985	156,382	40,706,198	12,627	477,013	(*c*)	111,513,119
1899	346,042	9,395	152,687	2,409,889	16,684	574,867	(*c*)	29,846,779
1900	286,179	12,902	224,396	4,945,443	17,896	698,263	(*c*)	91,791,986

(a) From data furnished to THE MINERAL INDUSTRY by the Japanese Government. (b) Included in other kinds. (c) Not stated.

PORTUGAL.

THE mineral statistics of Portugal are summarized in the subjoined table, for which we are indebted to the courtesy of Senhor Severiano Augusto da Fonseca Monteiro, chief of the Reparticao de Minas, Ministerio das Obras Publicas of Portugal.

The statistics of mineral production in Portugal in years prior to 1897 may be found in THE MINERAL INDUSTRY, Vol. III. and Vol. VIII. The mineral industry of Portugal has not yet attained much importance, the output of copper and copper ore forming the chief part of the total. This is principally the production of Mason & Barry Co., Ltd.

MINERAL PRODUCTION OF PORTUGAL. (*a*) (IN METRIC TONS AND DOLLARS; 1 milreis = $1·08.)

Year.	Antimony Ore.		Arsenic.		Coal. (Anthracite.) (*b*)		Coal. (Lignite.) (*b*)		Copper Ore.		Copper. (Cement.)	
1897..	418	$28,063	524	$20,369	7,996	$32,816	9,342	$24,215	241	$4,496	3,304	$408,202
1898..	245	6,786	751	44,764	10,250	37,032	12,291	52,656	290	12,799	3,149	533,581
1899..	59	2,123	1,083	61,356	11,930	46,398	10,269	41,161	408	29,920	2,521	520,099
1900..	38	554	1,081	62,522	24,066	90,777	(*c*)	.....	(*c*)	.....	2,948	513,226
1901..	(*c*)	.....	527	35,277	15,000	55,881	(*c*)	.....	(*c*)	.....	2,061	340,067

Year.	Copper Pyrites.		Copper Pyrites. (Dressed.)		Gold Ore.		Iron Ore.		Lead Ore. (Galena.)		Manganese Ore.	
1897.....	66,473	$178,014	210,265	$287,254	17·0	$12,085	(*c*)	.....	2,180	$56,300	1,652	$11,596
1898.....	54,368	133,899	248,218	366,258	6·8	4,687	2,519	$3,265	3,242	109,480	907	2,595
1899.....	71,576	358,128	275,658	378,018	13·0	78	15,078	25,564	3,468	104,627	2,949	21,484
1900.....	57,540	183,550	345,320	539,044	*e* 2·6	1,728	19,803	46,247	3,020	116,346	1,971	10,437
1901.....	98,316	354,531	345,081	521,720	*e* 2·0	1,868	21,599	38,451	445	9,790	904	5,858

Year.	Silver—Kg.		Tin Ore.		Tungsten Ore.	
1897	79	$2,042	*d* 9	$2,550	29·4	$7,263
1898.....	119	2,362	102	23,278	59·3	16,714
1899.....	(*c*)	.....	30	9,418	55·0	13,513
1900.....	(*c*)	.....	81	26,017	49·0	8,677
1901.....	(*c*)	.....	31	13,366	90·0	12,994

(*a*) From a report specially furnished THE MINERAL INDUSTRY by Senhor Severiano Augusto da Fonseca Monteiro, Chief of the Department of Mines of the Ministerio das Obras Publicas. (*b*) Consumed in the country. (*c*) No report. (*d*) Includes metallic tin and cassiterite. (*e*) Gold metal, kilograms. In 1902, 79 metric tons ($3,498) gold and antimony concentrates.

MINERAL EXPORTS OF MEXICO (a) IN METRIC TONS AND MEXICAN DOLLARS (c)

Year	Antimony Ore		Asphalt		Building Material		Coal		Copper Ore		Copper Ingot	
1897	5,878	$71,485	10	$200	1,808	$7,858	105,250	$434,624	1,084	$171,391	10,658	$1,221,37
1898	5,952	98,815	(b)	.....	587	8,561	116,538	466,506	13,140	1,736,738	10,262	1,315,78
1899	10,382	115,292	6	1,000	956	5,928	118,182	455,308	225	54,628	27,586	7,811,40
1900	2,812	28,819	827	12,815	2,628	9,804	88,670	157,262	408	49,786	27,970	1,45 ,00
1901	5,108	51,605	146	5,529	687	3,305	17,397	70,122	5,576	1,472,165	25,654	10,22 ,50

Year.	Gold.					Graphite.		Gypsum.	
	Coin.	Ore.	Bullion.	Cyanide	Sulphide.				
1897	$382,222	$305,226	$6,220,705	$236,986	$88,916	750	$6,000	2,805	$7,75
1898	(b)	1,087,262	6,668,735	294,720	64,062	(b)	.....	1,650	3,50
1899	198,474	335,844	7,017,296	115,961	986,792	2,305	22,447	1,650	3,50
1900	192,456	306,262	7,635,964	128,675	177,195	2,561	25,650	1,650	3,00
1901	219,621	264,722	6,224,041	176,958	81,744	762	7,615	800	2,50

Year.	Iron Ore.		Jewels and Precious Stones. Grams.		Lead. Ore.		Lead. Base Bullion.		Marble.		Pearls—Carats	
1897	(b)	.....	3,990	$5,079	149	$97	60,029	$3,006,921	2,176	$185,004	1,620	$6,000
1898	21	$200	11,241	27,997	(b)	.....	60,918	3,291,014	469	46,724	2327	3,500
1899	(b)	.....	2,499	911	140	175	67,441	3,985,747	370	33,220	.....	17,000
1900	(b)	.....	1,447	975	4660	11,425	74,944	4,278,608	1,050	108,759	(b)	.....
1901	66	3,595	3,192	542	(b)	.....	79,097	4,509,074	1,083	120,877	(b)	.....

Year.	Quicksilver. Kg.		Silver. Coin.	Silver. Ore.	Silver. Slag.	Silver. Bullion.	Silver. Sulphide.	Silver. Cyanide	Tin.	
1897	1,845	$3,150	$21,925,547	$11,401,176	$39,900	$35,775,125	$1,663,581	$123,246	0·6	$0
1898	(b)	.....	(b)	11,048,858	46,488	37,187,599	1,663,501	257,342	(b)	.....
1899	(b)	.....	5,580,884	10,760,099	4,810	37,585,911	1,929,085	76,942	.....	.....
1900	(b)	.....	22,079,666	12,495,524	87,998	41,468,745	1,893,646	67,607	·096	43
1901	(b)	.....	12,088,158	9,615,980	98,549	36,348,374	2,141,685	259,282	(b)	.....

(a) From the *Estadística Fiscal*. The figures for 1901 are from the *Anuario Estadístico de la República Mexicana*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. Additional exports 1898: salt, 1,538 metric tons, $13,449; zinc ore, 1,001 metric tons, $10,010. (b) Not reported. (d) There was also exported pearls, 42 g., $1,000. (e) The average value of the Mexican dollar in New York was, in 1897, $0·4671; in 1898, $0·4641; in 1899, $0·473; in 1900, $0·509; in 1901, $0·490.

NOTE. There was exported of zinc in 1900, 688 metric tons, worth $6,384; of zinc ore, 1,027 tons, worth $9,995; of salt, 1,518 tons, worth $4,151. Of minerals classed in the *Boletín de Estadística Fiscal* as "other mineral products not specified," there were exported 749 tons, valued at $5,347. Additional exports in 1901: zinc ore, 166 tons, worth $16,639; salt, 490 tons, worth $3,898 and mineral products not specified, 38 tons, worth $6,909.

NORWAY.

[illegible] statistics of mineral production, imports and exports, are summarized in the following tables.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Year.	Steel.		Locomotives and Machines.	Lead, in Pigs and Sheets.		Lead White and Zinc Oxide.		Paraffin Oil, Petroleum, etc.		Potash.	
1897.....	4,350	$246,645	$2,058,885	848	$54,972	1,119	$93,636	39,810	$1,021,113	919	$76,928
1898.....	2,428	144,234	2,437,371	732	51,408	1,491	140,886	36,504	867,051	754	63,069
1899.....	2,652	164,673	2,883,509	869	66,744	1,296	139,995	42,182	1,138,914	902	77,496
1900.....	2,085	152,010	2,259,630	670	59,670	1,216	131,490	39,657	1,070,890	638	59,940
1901.....	1,905	118,260	1,534,410	590	42,930	1,321	135,540	47,011	1,142,870	518	46,870

Year.	Salt, *Hektoliters.*		Saltpeter.		Soda.		Sulphur. (*b*)		Tin, in Blocks, etc.		Zinc, in Plates, Bars, etc.	
1897.....	1,645,716	$630,968	277	$15,708	5,492	$59,319	10,701	$260,087	236	$82,917	1,102	$107,092
1898.....	1,273,405	498,211	477	34,776	4,823	52,083	9,589	258,903	257	98,307	1,370	162,729
1899.....	*d*184,583	508,734	278	20,250	4,555	61,506	10,734	289,818	546	314,226	1,509	332,905
1900.....	1,434,000	619,380	356	25,920	4,576	61,880	14,827	400,410	149	100,340	1,254	149,040
1901.....	1,276,000	489,240	208	15,120	5,220	84,510	11,149	301,050	141	89,640	1,027	110,970

MINERAL EXPORTS OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Apatite.		Clay Products.				Cobalt Ore—Kg.		Copper.			
			Bricks. *Thousands.*		Earthenware.				Ore.		Ingot.	
1897.....	872	$12,960	11,711	$59,454	260	$27,378	45,000	$9,720	15,111	$204,012	532	$131,031
1898.....	3,593	58,852	15,534	69,677	2	243	25,000	5,400	13,587	183,411	444	113,886
1899.....	1,500	22,275	11,949	56,457	2	270	*Nil.*	.....	7,198	116,613	747	242,001
1900.....	300	4,590	5,266	17,010	2	270	*Nil.*	.....	5,756	93,150	728	253,800
1901.....	738	11,070	12,103	35,910	7	810	*Nil.*	.....	6,041	89,640	691	253,260

Year.	Copper—*Con.*		Feldspar.		Glassware.		Iodine—Kg.		Iron.			
	Old Metal.								Ore.		Pig and Old.	
1897.....	670	$81,459	17,302	$70,830	1,432	$78,894	2,395	$11,151	4,242	$8,019	4,631	$53,136
1898.....	1,206	156,249	11,355	49,059	841	31,212	5,474	29,565	4,601	8,694	3,844	44,118
1899.....	1,688	224,316	19,280	78,008	840	26,888	16,180	87,372	12,517	23,652	6,065	69,822
1900.....	1,168	208,110	17,609	71,280	1,531	40,230	11,210	49,680	27,158	55,080	8,141	98,809
1901.....	774	156,870	18,323	74,250	2,142	70,470	10,000	38,880	39,173	63,450	3,250	35,100

Year.	Iron.—*Continued.*				Steel.		Machinery.		Nickel Ore. Kg.	
	Bars and Hoops.		Nails and Spikes.							
1897.....	56	$2,376	9,097	$636,552	167	$9,936	992	$267,840	(*c*)	.....
1898.....	25	1,134	7,270	499,402	158	9,369	507	136,971	30,000	$135
1899.....	337	16,848	6,089	463,833	377	22,410	464	125,928	63,200	351
1900.....	135	8,640	5,643	460,350	220	17,820	811	218,970	272,000	1,620
1901.....	370	18,900	6,001	439,290	179	12,690	980	264,600	55,000	270

Year.	Pyrites.		Silver Ore—Kg.		Stone, Ashlar.		Whetstones.	
1897.....	70,552	$288,113	118,000	$3,861	74,472	$367,065	112	$7,587
1898.....	67,502	286,925	79,000	2,565	98,692	546,264	137	9,261
1899.....	83,912	294,543	14,160	972	104,933	566,649	170	11,475
1900.....	84,604	456,840	90,210	4,860	100,914	490,320	136	9,180
1901.....	104,151	435,780	6,000	2,700	120,961	587,790	181	12,150

(*a*) From *Statistisk Aarbog for Kongeriget Norge.* (*b*) Inclusive of flowers of sulphur. (*c*) Not reported (*d*) Metric tons.

PORTUGAL.

RUSSIA.

THE official statistics of mineral production, imports and exports, are given in the subjoined tables. The Russian official statistics of production are somewhat tardy in appearance, the latest being for 1900.

MINERAL PRODUCTION OF RUSSIA. (*a*) (*b*) (IN METRIC TONS AND DOLLARS.)

Year	Asbestos.		Asphaltum.		Chrome Iron Ore.		Coal.		Cobalt Glance.	Copper.		Gold—Kg.	
1896	1,274	$7,000	22,102	$145,428	6,082	$16,816	9,877,551	$13,198,424	4	5,832	$1,494,076	37,199	$16,845,122
1897	1,022	37,444	22,222	184,016	18,433	32,804	11,208,738	15,578,184	3	6,940	1,961,539	38,198	17,255,532
1898	1,005	60,000	12,018	128,176	15,467	37,000	12,807,450	17,148,000	3	7,290	2,183,531	38,830	17,250,141
1899	2,068	97,342	23,081	170,380	19,146	46,742	14,274,861	22,801,400	4	7,533	2,682,800	38,935	17,415,522
1900	3,845	(c)	23,000	(c)	18,234	(c)	16,156,038	32,877,200	216	8,258	2,924,000	38,771	17,519,075

Year.	Graphite.		Iron, Cast.		Kaolin.		Lead.		Manganese Ore.		Petroleum.		Phosphorites.	
1896	...	.....	1,620,812	$25,315,436	6,099	$24,573	202	$12,775	208,025	$398,000	7,105,768	$12,588,860	3,776	$11,065
1897	98	.....	1,880,135	31,636,289	5,096	20,244	450	25,285	370,190	1,102,124	7,881,254	14,623,058	5,917	22,182
1898	20	.....	2,211,200	40,472,800	6,648	30,320	241	13,560	329,276	633,031	9,002,190	19,860,631	1,870	4,784
1899	...	.....	2,708,749	48,460,000	7,406	34,050	322	18,079	659,201	1,096,000	9,809,105	34,607,306	16,863	58,640
1900	...	.....	3,033,783	50,120,000	32,821	(c)	221	13,480	802,234	784,000	10,378,002	39,788,000	29,663	(c)

Year.	Platinum—Kg.		Pyrites.		Quicksilver.	Salt.		Silver—Kg.		Sodium Sulphate.
1896	4,920	$1,088,000	11,550	$82,435	491	$432,058	1,346,947	$2,079,398	7,813	$235,172	5,198	$9,600
1897	5,082	1,238,040	19,380	54,456	616	541,440	1,551,894	2,711,077	4,783	172,581	7,220	13,352
1898	6,011	1,439,912	24,570	68,800	382	321,754	1,505,600	2,566,906	5,143	182,500	5,045	9,216
1899	5,982	1,754,480	23,251	57,240	362	321,814	1,681,362	2,767,168	4,422	168,082	7,466	10,988
1900	5,094	1,662,850	23,154	(c)	304	332,000	1,968,006	3,124,000	2,293	34,432	5,036	(c)

Year.	Sulphur.		Tin.		Zinc.	
1896	437	$5,239	2	$476	6,257	$458,369
1897	574	11,917	2	476	5,898	549,114
1898	1,018	21,244	...	.....	5,664	531,124
1899	451	9,412	...	.....	6,328	575,706
1900	1,587	(c)	4·2	(c)	5,963	509,000

(*a*) From the Russian official mining report "Sbornik Statisticheskich Svedenie o Gornozavodskoi Promyshlennosti Rossie v Zavodskom Godu," St. Petersburg. (*b*) In the Russian reports the quantities are stated in pounds and the values in silver rubles. In making the reductions the following relations were employed: 1 pood = [illegible] metric ton; 1 silver ruble = 40 cents. (*c*) Not reported.

MINERAL PRODUCTS OF BURMA (IN METRIC TONS AND [illegible])

Year	Asbestos	Asbestos Manufactures	Asphalt Rock	Barytes and Witherite	Clay Products and Tile	Gem Stones	Gold	Graphite
[illegible]								

Year	Copper and Matte	Copper and Brass Manufactures	Chromite Ore	Coal and Lignite	Coke	Cement	Fig
[illegible]							

Iron (continued)

Year	Tin Plate	All Other	Iron and Steel Manufactures	Lead All Kinds	Lead	Magnesite
[illegible]						

Year	Wire Rope	Vegetable Fibres	Iron and Steel Manufactures	Other Metals	Manufactures	Petroleum	Pig Iron
[illegible]							

Year	Quicksilver	Salt	Tin Concentrates	Tin Metal	Tungsten Ore	Zinc Concentrates and Blende	Zinc Metal
[illegible]							

Year	Tin Asphalt Manufactures	Tin	Iron and Steel Manufactures	[illegible]
[illegible]				

MINERAL EXPORTS OF BURMA (IN METRIC TONS AND [illegible])

Year	Chromite and Manufactures	Clay Products and Tile	Coal and Lignite	Coke	Cement and Manufactures	Gem Stones and Pearls	Gold
[illegible]							

Year	Iron. Castings		Iron. Pig.		Iron. All Other.	Manganese Ore.	Metals, Other		Naphtha. Crude		Naphtha. Benzine	
1905..	258	$30,970	192	$7,080	2,312	$117,297	146,849	$1,194,085	242	$39,314	9,298	$22,456
1906..	429	39,011	184	7,359	4,534	229,659	165,966	1,215,269	127	12,150	2,942	40,534
1907..	547	60,124	228	6,708	4,150	184,139	147,206	1,178,424	(c)	.....	9,645	67,576
1908..	394	29,497	134	4,028	2,655	139,054	245,081	1,285,355	178	44,524	5,657	44,589
1909..	725	68,928	122	3,954	4,028	212,000	205,000	2,245,000	117	13,223	4,500	34,988

Year	Oil, Kerosene, Benzine, etc.		Ores of Metals and Minerals, Except Graphite.		Paraffin.		Phosphorites.		Platinum, Crude—Kg.		Quicksilver.	
1905..	709,405	$5,642,007	432	$10,200	b1	$370	10,918	$134,946	4,589	$[illegible]	140	$154,336
1906..	845,751	8,129,730	20,026	40,071	148	2,746	8,540	107,498	4,700	[illegible]	430	30,629
1907..	917,216	9,507,619	16,800	40,874	b749	15,516	2,917	36,309	4,767	[illegible]	643	53,540
1908..	1,115,106	10,566,454	15,804	110,392	65,197	52,516	1,604	26,465	4,175	[illegible]	354	21,084
1909..	1,280,313	11,771,924	13,696	68,801	68	680	5,629	70,700	3,428	1,142,732	338	20,64

Year.	Salt.		Silver.	Slags.		Steel.		Zinc. Ore.		Zinc. Ingot and Sheet.	
1905..	7,023	$17,790	.....	5,173	$11,384	167	$14,855	208	$2,080	1·0	$46
1906..	6,814	16,461	.....	5,606	11,274	173	15,338	194	4,390	3·5	84
1907..	9,082	21,698	.....	9,702	22,447	160	17,579	.....	.....	12·4	1,552
1908..	9,534	25,008	$1,804,000	17,036	40,878	312	28,989	.....	.....	76·9	5,908
1909..	7,852	20,151	.....	13,905	28,259	174	16,242	302	4,849	56·0	3,327

(a) From the Russian official report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennosty Rossie v Zavodskom Godu," St. Petersburg. (b) Includes vaseline. (c) Not reported.

SPAIN

[illegible] statistics of [illegible] production, imports and exports, are summarized [illegible] following tables.

[illegible] AND METALLIFEROUS PRODUCTION OF SPAIN [illegible] IN METRIC TONS AND [illegible] OF [illegible] pesetas

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Year	Lead Ore: Argentiferous		Lead Ore: Non-Argentiferous		Manganese Ore		Mineral Waters		Other	
1897	[illegible]	[illegible]	140,000	$2,450,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1898	[illegible]	[illegible]	150,672	6,349,464	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1899	[illegible]	[illegible]	122,756	4,776,648	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1900	[illegible]	[illegible]	131,627	5,440,629	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1901	207,158	6,715,519	174,326	2,782,188	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Year	Phosphorites		Pyrites		Pyrites (Arsenical)		Quicksilver		Quicksilver Ore		Salt	
1897	2,154	$16,872	160,000	$ 480,000	(b)	.....	1,720	$1,564,338	32,309	$1,239,443	398,676	$1,159,294
1898	4,500	45,000	70,295	35,148	280	$837	1,091	1,000,921	31,331	1,252,694	479,359	1,035,892
1899	8,510	85,100	107,395	142,192	(b)	.....	1,301	1,051,220	32,144	1,274,008	598,108	1,091,133
1900	4,170	18,500	24,000	24,247	515	515	1,085	1,079,373	39,216	1,104,237	450,941	834,535
1901	4,200	16,000	25,000	25,000	1,204	1,204	754	1,105,680	27,387	1,040,107	345,063	599,304

Year.	Silver Kg.		Silver Ore.		Soapstone.		Sulphur.		Sulphur, Crude Rock.	
1897	71,199	$1,555,000	982	$101,797	3,071	$21,241	3,500	$70,000	18,845	$32,598
1898	76,295	1,665,155	787	105,094	2,613	14,504	3,100	68,400	e105,757	198,128
1899	89,409	2,161,551	764	78,721	4,944	26,622	1,100	31,350	58,922	102,150
1900	140,497	3,651,910	742	121,005	8,109	46,004	750	18,000	64,364	109,967
1901	94,977	2,346,069	391	59,187	4,880	29,061	610	13,115	49,856	59,806

Year.	Tin Ore.		Topaz of Hinojosa. Kg.		Tungsten Ore		Zinc. Ore.		Zinc. Sheet.		Zinc. Slabs.	
1897	10,879	$5,795	44	$751	10	$309	73,848	$363,846	2,337	$378,594	3,907	$445,212
1898	4	408	90	1,454	37	5,925	99,896	991,896	1,731	282,040	4,300	602,000
1899	57	8,450	44	751	151	14,142	119,710	1,208,987	2,084	287,694	4,100	574,000
1900	47	7,168	95	751	1,958	100,339	86,158	617,651	2,756	512,616	2,855	399,784
1901	115	10,091	810	1,195	6	488	119,708	805,805	2,781	517,266	2,573	360,234

(a) Figures for 1897 are from the *Reports of the Comisión Ejecutiva de Estadística Minera*. The figures for 1898 are from the official *Reports of the Junta Superior Facultativa de Minas*, Madrid. There was also produced in 1897, gold ore, 450 metric tons, $1,850; lead and zinc ores, 40 metric tons, $40; in 1898, lead and zinc ore, 99 tons, $198; gold, $2,838. (b) Not reported. (c) Represents non-argentiferous copper ore. (d) Undressed ore. (e) 70,814 tons, $158,809, of this product is the contents of copper pyrites from Huelva. (f) Gold ore only.

MINERAL IMPORTS OF SPAIN. (a) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Asphalt and Pitch.		Alkaline Carbonates		Coal.		Coke. (b)		Gold Bars—Kg.	
1897	98,894	$508,710	98,498	$1,210,436	1,633,333	$8,687,595	214,783	$1,159,731	388	$15,670
1898	98,736	450,589	96,574	1,169,945	1,294,345	7,466,073	196,294	1,177,346	[illegible]	1,440
1899	87,897	605,281	84,805	1,295,614	1,555,809	9,194,808	208,789	1,252,735	10,270	7,353,000
1900	99,993	479,732	81,463	1,296,519	1,794,119	14,352,956	197,516	1,580,134	(c)	.....
1901	92,809	531,119	99,470	1,255,663	1,966,094	12,589,558	197,104	1,361,985	(c)	.....

Year	Gold Coin	Iron, Pig.		Iron, Bar.		Iron and Steel, Forged.		Petroleum, Crude.		Silver Bars, Kg.	
1897	$19,140	1,855	$25,972	13,558	$371,043	24,087	$1,472,680	34,972	$1,259,[illegible]	[illegible]	[illegible]
1898	(c)	1,575	20,332	(c)	.....	5,164	267,139	32,731	1,346,[illegible]	[illegible]	[illegible]
1899	(c)	2,267	40,798	(c)	.....	5,687	338,119	33,322	1,402,409	86,564	1,298,74
1900	(c)	4,717	113,227	(c)	.....	5,404	289,465	42,969	1,733,679	(c)	.....
1901	(c)	4,980	101,460	14,573	682,917	6,351	376,989	37,392	1,368,[illegible]	(c)	.....

[illegible]

SWEDEN.

THE official statistics of mineral production, imports and exports are summarized as follows:

MINERAL PRODUCTION OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Clay (Fire).		Coal.		Cobalt Oxide. Kg.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.	
1897..	131	$3,826	112,283	(c)	224,343	$434,710	700	$2,457	280	$68,645	282	$3,235	25,207	$92,712	1,315	$99,860
1898..	153	4,543	131,391	(c)	236,277	465,936	3,001	10,125	235	59,689	124	1,788	23,335	99,749	1,165	78,840
1899..	164	4,917	129,875	(c)	230,344	485,239	1,345	4,536	179	60,028	105	1,483	22,334	110,402	1,287	108,000
1900..	167	4,402	160,885	62,200	252,320	550,721	*Nil.*	.....	136	45,830	18	2,306	22,725	92,678	1,265	125,000
1901..	121	3,612	175,876	82,647	271,509	635,911	*Nil.*	.....	137	45,050	140	2,289	23,660	102,111	1,224	125,590

Year.	Feldspar.		Gold—Kg.		Gold Ore.		Iron. Pig.		Iron. Bloom.		Iron Ore.		Iron Ore. (Bog.)	
1897..	19,268	$53,992	113·3	$75,517	1,662	$9,214	538,197	$9,467,855	189,633	$5,045,705	2,086,119	$2,700,639	1,047	(c)
1898..	20,737	64,572	125·9	106,318	2,136	6,136	581,766	9,414,123	198,923	5,407,843	2,302,546	2,969,986	392	(c)
1899..	16,017	50,041	106·2	71,081	*Nil.*	.....	497,727	9,823,735	195,331	5,866,020	2,434,606	3,627,517	594	(c)
1900..	15,228	46,457	88·5	55,224	*Nil.*	.....	526,868	11,988,097	188,455	6,324,423	2,607,925	3,738,237	1,575	2,251
1901..	13,502	44,264	62·7	42,305	*Nil.*	.....	528,375	11,276,019	164,850	5,153,442	2,793,566	3,900,555	1,594	1,966

Year.	Iron and Steel Bars, Rods, Sheets, etc.		Lead.		Lead Ore.		Manganese Ore.		Pyrites.		Silver. Kg.	
1897	304,537	$12,624,486	1,480	$76,876	99	$3,240	2,749	$12,810	517	$1,496	2,218	$41,471
1898	299,846	11,943,458	1,559	102,464	50	1,620	2,358	11,142	386	1,037	2,083	38,887
1899	328,999	14,223,434	1,606	106,846	35	1,134	2,622	12,080	150	364	2,290	43,411
1900	324,604	14,790,197	1,424	105,697	85	2,950	2,651	12,294	179	385	1,927	35,831
1901	299,507	11,661,968	988	62,752	56	2,836	2,271	11,340	*Nil.*	.....	1,557	30,249

Year.	Silver and Lead Ore.		Steel. Bessemer.		Steel. Crucible.		Steel. Martin.		Sulphur.		Zinc Ore		Zinc Ore. (Calcined.)	
1897....	10,068	$63,123	107,679	$3,091,109	691	$73,540	165,886	$4,652,524	(c)	.....	56,636	$494,742	24,583	$358,429
1898....	6,743	38,631	102,254	2,896,079	1,013	106,318	160,706	4,512,212	50	$1,620	61,627	603,647	25,250	443,137
1899....	5,730	60,070	91,898	2,710,926	1,225	126,705	179,357	5,549,606	(c)	.....	65,159	743,869	24,200	516,186
1900....	5,300	65,534	91,065	2,968,514	1,121	102,803	207,418	6,768,626	70	1,750	61,044	477,084	26,772	401,580
1901....	11,366	56,907	77,281	2,360,772	1,088	94,015	190,877	6,115,791	(c)	.....	48,630	382,894	26,160	360,223

(*a*) From *Bidrag till Sveriges Officiela Statistik. Bergshandteringen.* In 1899 there was also an output of 500 tons of graphite ore valued at $540. (*c*) Not reported.

MINERAL IMPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Aluminum Sulphate.		Ammonium. Carbonate.		Chloride.		Hydrate.		Nitrate.		Sulphate.		Antimony Crude.	
1897..	103	$3,072	733	$9,896	109	$20,516	110	$20,873	59	$5,605	42	$9,013	67	$4,536	58	$11,053
1898..	136	4,036	968	13,074	99	18,723	101	19,168	105	9,886	12	2,565	81	5,477	53	9,936
1899..	158	4,688	866	11,690	89	16,900	112	21,264	110	10,391	12	2,561	181	12,221	59	11,170
1900..	133	3,948	1,197	16,165	141	13,329	99	18,875	100	18,923	5	1,129	227	15,297	85	16,151
1901..	346	10,266	1,192	16,058	131	12,380	113	21,449	98	17,382	1	253	235	19,235	50	19,544

Year.	Tin Salts. Kg.		Zinc.	
1897....	3,823	$1,082	2,551	$261,249
1898....	3,874	1,046	3,030	343,014
1899....	5,404	1,459	2,829	343,758
1900....	3,243	876	2,912	319,893
1901....	2,334	630	2,900	289,428

(*a*) From *Bidrag till Sveriges Officiela Statistik.* (*c*) Includes raw product and manufactured articles. (*d*) Natural and artificial asphalts. (*e*) Ground chalk, pastels, etc. (*f*) N. E. S.—*Not elsewhere specified.* (*g*) Includes coal-dust. (*h*) Exclusive of powdered glass. (*i*) Includes also sodium bisulphate. (*j*) Raw, ground and calcined gypsum. (*k*) Slaked and unslaked lime. (*l*) Includes both sodium and potassium salts. (*m*) Building stone, etc.

MINERAL EXPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Ammonium Sulphate.		Antimony, Crude.		Asbestos. Kg.		Cement.		Chalk.				Chemico-Technical Preparations.
											Unground. *Hektoliters.*		All Other.		
1897....	54	$1,604	180	$12,150	0·8	$156	1,348	$364	27,112	$319,611	1,188	$128	4,422	24,082	$40,351
1898....	32	947	36	2,491	4·7	896	1,055	285	28,676	232,276	365	39	4,844	26,209	80,377
1899....	26	772	2	124	2·6	497	2,812	759	31,101	251,917	616	66	5,392	29,550	124,948
1900....	24	674	2	120	4·6	880	2,436	658	42,564	344,771	195	21	5,313	28,788	304,145
1901....	56	1,642	156	10,717	1·8	336	2,179	538	17,794	144,130	940	101	5,193	28,102	322,832

Year.	Clay.	Clay Manufactures.	Coal.		Copper and Iron Sulphates	Copper Ore.		Copper and Copper in Alloys and Metals.		Glass, All Kinds.		Graphite. Kg.	
1897....	$28,931	$684,340	74	$325	$97,449	(*b*)	.....	983	$425,089	9,399	$1,134,495	7,215	$390
1898....	43,005	641,730	496	2,513	92,191	1,102	$7,441	1,346	298,159	9,898	1,143,037	9,108	492
1899....	46,589	642,079	702	4,112	129,676	315	3,337	1,890	269,423	9,194	756,683	16,664	900
1900....	50,796	750,177	1,108	6,282	124,498	448	3,313	2,012	543,201	10,000	848,488	17,719	957
1901....	37,462	656,077	716	3,803	106,897	602	4,468	1,243	432,318	13,002	898,916	16,761	905

Year.	Gypsum and Manufactures.		Iron Ore.		Iron and Steel.			Lead and Manufactures.		Lime. *Hektoliters.*	
					Unwrought.		Manufactures.				
1897....	9·6	$5,727	1,400,801	$2,779,890	279,525	$9,175,910	$2,873,290	1,473	$91,993	106,053	$31,925
1898....	27·3	2,609	1,439,860	2,942,980	301,192	9,399,827	1,644,096	570	36,090	133,999	40,401
1899....	8·3	1,384	1,628,011	3,406,613	320,742	11,398,918	2,109,433	818	62,049	80,153	25,391
1900....	10·4	1,182	1,619,902	3,525,230	304,175	13,473,711	2,045,204	1,209	98,271	84,242	26,871
1901....	54·5	1,645	1,761,257	3,775,783	268,143	9,448,279	1,965,242	1,098	64,296	69,000	24,189

Year.	Peat.		Phosphorus. Kg.		Potassium Chlorate.		Salt, Refined. Kg.		Sand.	Silver.			
										Bullion—Kg.		Manufactures—Kg.	
1897....	1,816	$4,902	1,627	$1,977	462·5	$74,927	1,424	$69	$969	329	$6,396	119	$6,426
1898....	1,616	4,364	4,085	4,963	506·4	82,041	216	11	3,336	130	2,492	228	12,744
1899....	1,979	5,342	1,890	2,296	334·9	54,259	110	5	1,999	367	7,134	258	13,929
1900....	3,843	9,776	875	1,063	930·7	150,783	407	18	2,084	296	5,968	103	5,562
1901	3,064	8,273	1,254	1,524	707·9	114,679	1,556	76	1,261	179	3,456	9	486

Year.	Soda.		Sodium Sulphate.		Stone. (*c*)	Sulphur.		Sulphuric Acid.		Tin and Lead Ash.		Tin.		
												Ingot.	Manufactures—Kg.	
1897....	686	$12,970	3·4	$46	$2,062,011	11	$358	7·6	$205	1·7	$1,836	25·6	$8,305	7,113	$4,338
1898....	509	9,618	5·1	69	2,385,736	11	372	2·8	76	15·8	17,013	20·8	7,591	1,363	794
1899....	227	4,298	13·2	180	2,613,158	68	730	2·7	74	20·6	22,211	8·8	5,371	1,033	582
1900....	238	4,871	20·5	389	2,804,594	20	474	16·5	447	11·9	12,882	21·5	13,985	1,521	849
1901....	237	4,471	14·1	304	2,737,266	12	289	6·3	171	22·4	24,194	20·4	11,809	8,110	4,759

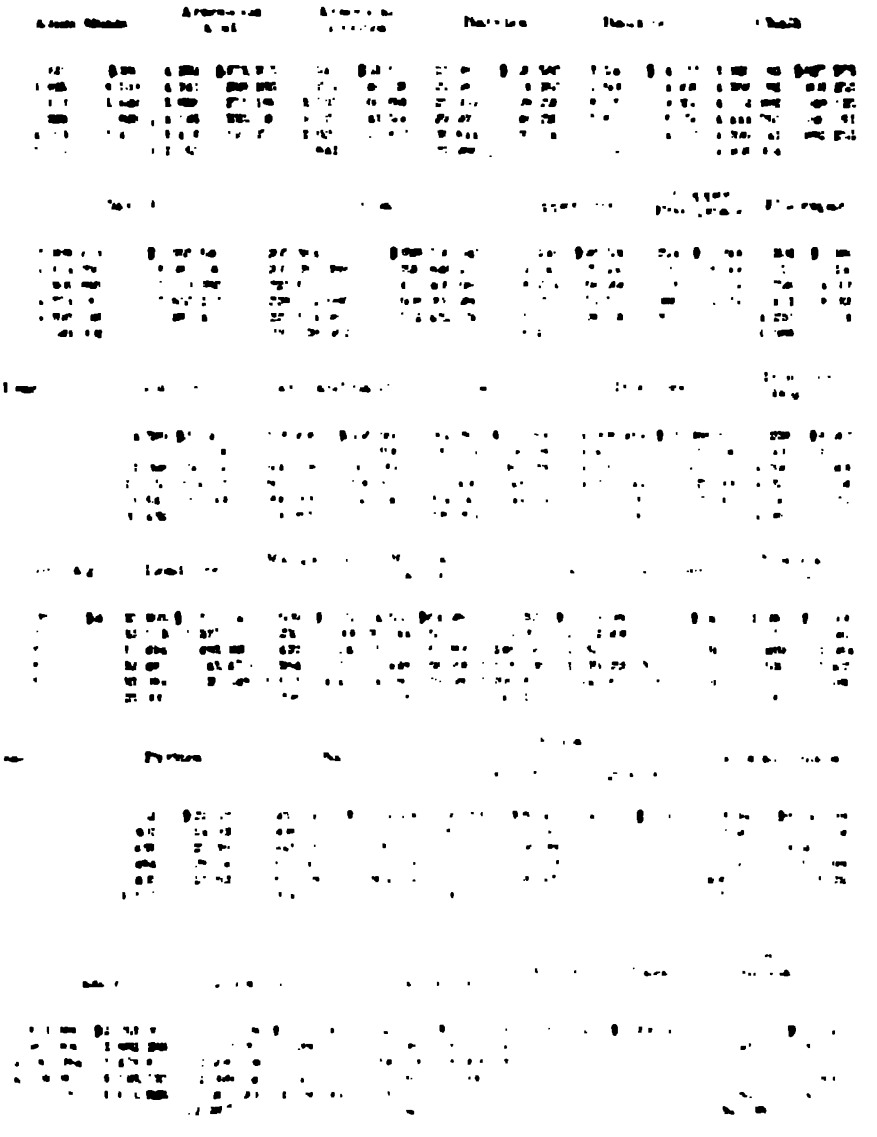
Year.	Zinc.				Minerals, Not Specified.	
	Ore.		Crude and M'f'rs.			
1897.....	44,425	$527,769	135	$9,009	442	$5,423
1898.....	49,597	723,129	184	13,799	2,596	40,596
1899.....	45,634	788,564	157	13,324	197	1,597
1900.....	40,879	518,749	156	12,274	288	2,332
1901.....	41,248	434,340	101	6,387	880	13,079

(*a*) From *Bidrag till Sveriges Officiela Statistik*, Handel. (*b*) Not stated in the reports. (*c*) Building stone, etc., wrought and unwrought.

UNITED KINGDOM.

[illegible] of the mineral production, imports and exports are given in [illegible] The statistics of the mineral industries of the United Kingdom for [illegible] are the most complete and reliable [illegible]

[illegible] Mineral Statistics and Statistics &c.—Gt.



Year.	Tin Ore (Black Tin).		Tungsten Ore.		Uranium Ore.		Zinc Ore.	
1897	7,234	$1,271,040	127	$10,040	20	$5,835	18,566	$345,770
1898	7,498	1,441,025	331	79,229	26	5,625	23,929	568,920
1899	6,494	2,202,545	96	19,155	7	1,375	23,560	607,410
1900	6,911	2,618,020	9	1,755	42	7,595	25,160	466,080
1901	7,407	2,292,905	21	2,040	60	14,615	23,967	353,930
1902	7,681	.....	9	.....	53	.....	25,460	.....

METALS OBTAINABLE BY SMELTING FROM THE ORES IN THE ABOVE TABLE. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Copper, Fine.		Gold—Kg.		Iron.		Lead.		Silver—Kg.		Tin.		Zinc.	
1897	526	$125,490	63·2	$35,925	4,942,679	$56,973,895	26,998	$1,602,860	7,750	$143,070	4,524	$1,456,630	7,162	$634,115
1898	650	177,615	12·3	6,495	4,929,347	63,700,215	25,761	1,664,975	6,575	118,640	4,722	1,729,000	8,711	897,910
1899	647	249,840	103·5	60,420	4,992,408	85,174,370	23,929	1,776,895	5,969	109,710	4,077	2,540,470	8,837	1,100,660
1900	777	209,975	437·6	290,735	4,743,172	97,984,550	24,762	2,094,800	5,964	112,325	4,337	2,989,345	9,214	942,865
1901	541	198,305	194·5	110,210	4,158,745	64,133,110	20,961	1,272,995	5,452	98,820	4,634	2,782,855	8,555	745,870

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Including china clay, potters' clay, and fuller's earth. (*c*) Included under copper ore. (*d*) Bog ore, which is raised in Ireland, is an ore of iron, used principally for purifying gas. (*e*) Not reported. (*f*) Not including chalk. (*g*) Included with granite. (*h*) Statistics not yet available.

Additional products: In 1897: Mica, 5,063 metric tons, $8,635; soapstone, 28 metric tons, $490; nickel ore, 305 metric tons, $1,500. Metals obtainable by smelting in 1897: Aluminum, 315 metric tons, $229,400; nickel, 7½ metric tons, $5,250; sodium, 86 metric tons, $63,750.

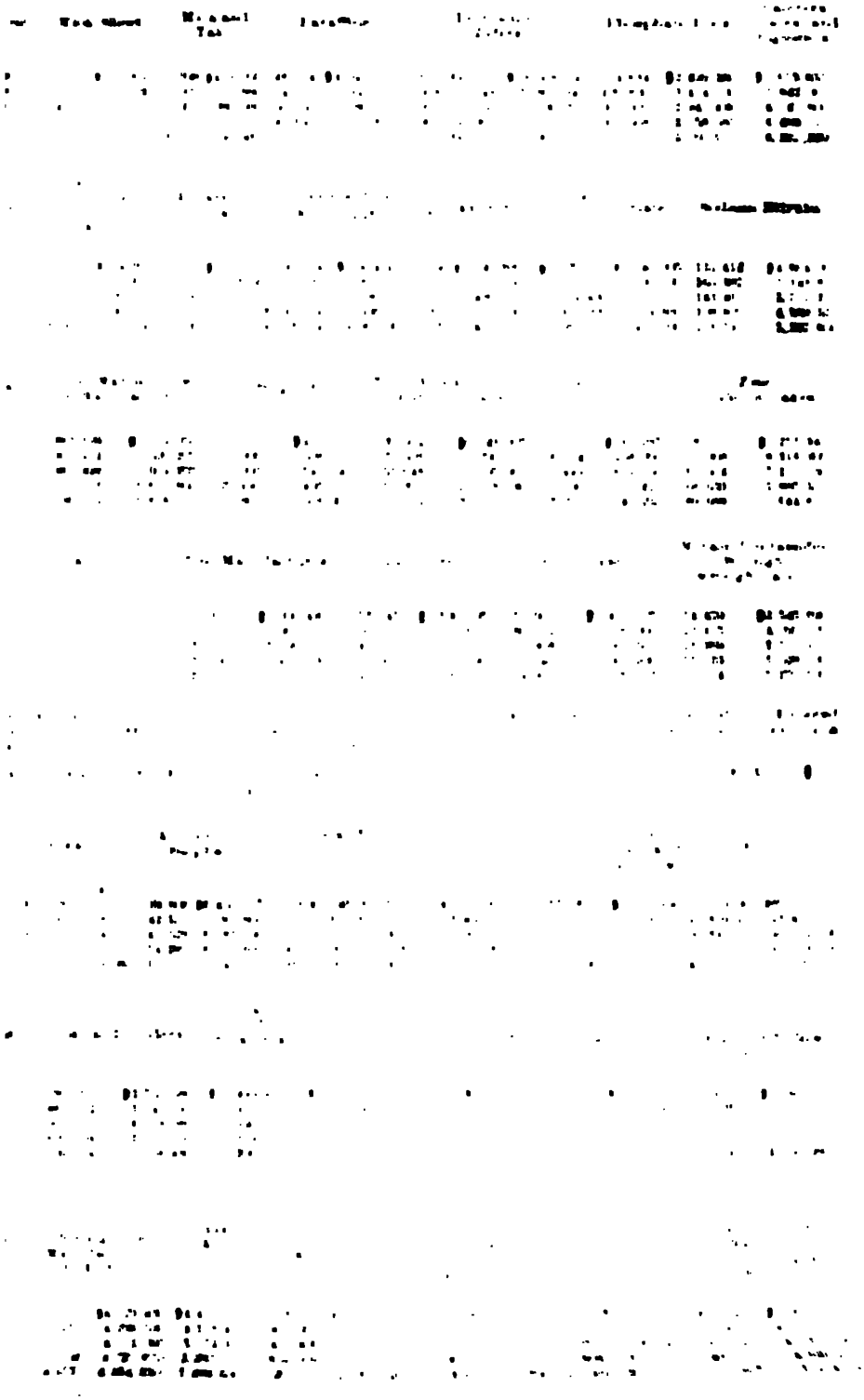
MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*) (METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Alkali.		Asphaltum.		Borax.		Brass and Bronze Manufactures.		Chemical Products.		Clay Products, Porcelain and Earthenware.		Coal, Culm and Cinders.		Copper Manufactures Unenumerated.	
		$														
1898	12,170	678,180	40,398	$635,110	1,255	$77,140	2,357	$1,068,380	$6,939,150		16,405	$4,301,740	11,191	$81,550	$2,602,400	
1899	12,078	669,300	59,078	807,840	3,070	154,075	1,988	919,980	7,478,170		18,341	4,604,100	1,777	16,985	3,408,800	
1900	16,860	840,700	53,061	728,355	15,667	777,045	2,335	1,086,180	7,417,490		18,329	4,647,390	10 112	60,770	5,248,255	
1901	c13,429	424,715	74,604	948,805	15,710	768,500	2,469	1,200,200	8,423,795		20,754	4,994,860	7,685	111,115	3,538,975	
1902	c20,202	819,110	65,806	817,415	13,390	500,785	3,408	1,476,255	8,514,545		19,020	4,907,405	3,331	20,505	4,277,770	

Year.	Copper.—*Continued.* Ore.		Regulus and Precipitate.		Wrought, Unwrought & Old.		Diamonds—*Carats.*		Glass, All Kinds.	Gold Leaf. *Number.*	
1898	91,141	$3,201,150	76,201	$9,770,790	70,018	$17,988,325	3,476,509	$22,619,075	$16,423,915	63,682,700	$634,960
1899	130,011	5,400,735	84,015	12,502,945	60,502	21,572,275	2,730,502	20,597,910	16,044,400	49,108,570	486,490
1900	102,305	5,803,110	80,123	17,587,530	72,223	30,309,730	1,882,073	17,168,180	15,997,555	54,346,025	540,955
1901	102,508	6,250,700	93,338	18,343,315	68,809	23,052,900	2,525,212	24,385,210	17,647,635	59,048,866	589,890
1902	90,007	4,891,085	74,084	12,532,365	92,349	24,600,940	2,634,207	26,901,950	18,484,960	59,334,028	591,920

Year.	Gold Ore.		Graphite.		Iron. Bar, Angle, Bolt and Rod.		Iron and Steel Mfres	Iron and Steel, Old and Scrap.		Ore.	
1898	1,019	$1,393,175	15,113	$1,500,805	70,331	$3,782,745	$33,379,160	24,619	$349,220	5,555,989	$20,173,210
1899	395	701,735	17,777	2,307,935	74,326	2,880,790	39,527,075	32,497	452,130	7,168,061	26,875,190
1900	(c)	1,432,970	14,969	1,733,805	81,436	3,280,070	40,131,630	31,687	559,720	6,396,639	28,195,015
1901	(c)	2,747,195	18,494	1,510,195	99,671	3,674,560	*f* 45,337,400	44,721	608,865	5,687,670	22,752,815
1902	(c)	2,688,170	13,506	1,148,930	174,666	5,423,065	*f* 46,864,645	39,589	564,090	6,342,798	24,895,770

Year.	Iron.—*Continued.* Pig and Puddled.		Steel, Unwrought.		Lead. Ore.		Pig and Sheet.		Manufactures.		Manganese Ore.	
1898	162,075	$2,688,445	40,875	$1,363,025	44,457	$1,512,535	197,591	$12,606,780	419	$66,830	136,390	$1,700,535
1899	174,159	3,104,255	78,257	2,170,100	30,262	1,269,560	201,551	14,419,185	341	62,415	261,748	2,927,105
1900	184,049	4,024,395	182,210	6,090,875	21,566	1,095,410	198,416	16,607,870	(*d*)	.....	270,098	3,422,180
1901	201,676	3,961,805	183,810	5,331,825	29,944	1,221,625	221,549	14,219,980	(*d*)	.....	195,736	2,288,300
1902	290,467	3,990,780	285,494	7,076,675	25,858	906,375	225,582	12,923,940	(*d*)	.....	227,468	2,284,050



Year.	Iron.—*Continued.* Hoops, Sheets (Ungalvanized) and Boiler and Armor Plates.		Galvanized Sheets.		Black Plates for Tinning. (Iron and Steel.)		Tinned Plates.		Cast and Wrought, and Manufactures, N. E. S. (*c*)	
1898....	102,638	$3,916,335	230,219	$12,653,350	59,299	$2,706,435	255,797	$13,768,540	361,927	$23,630,065
1899....	111,773	4,661,900	242,167	15,607,050	86,936	4,139,790	260,735	15,838,415	363,855	26,160,496
1900....	86,382	4,696,840	251,203	18,942,885	66,810	3,558,645	278,338	19,883,980	344,901	29,340,870
1901....	76,360	3,779,460	254,290	15,964,250	52,217	2,674,590	275,661	18,520,440	326,513	25,181,955
1902....	84,590	3,963,910	335,572	20,663,680	58,589	3,021,170	316,859	21,665,890	344,052	25,832,550

Year.	Iron.—*Concluded.* Old.		Steel, Unwrought.		Manufactures of Steel and Iron.		Total of Iron and Steel.	
1898.....	86,603	$1,201,050	290,182	$13,203,560	35,857	$4,513,470	3,299,826	$113,200,460
1899.....	118,262	1,952,620	338,887	16,842,310	45,181	5,109,295	3,777,028	140,463,900
1900.....	96,567	1,846,610	313,330	18,420,325	42,939	5,111,645	3,602,083	159,963,375
1901.....	86,559	1,366,615	217,296	11,827,385	52,681	5,724,425	3,250,456	126,410,400
1902.....	104,890	1,632,690	307,471	14,445,585	49,156	5,812,615	3,634,113	146,019,375

Year.	Lead. Pig.		Lead. Sheet, Pipe and Other Manufactures.		Mica and Talc.		Potassium Nitrate.		Salt, Rock and Brine.		Slate.
1898..	18,964	$1,231,360	19,720	$1,499,410	89	$69,065	1,343	$134,610	698,882	$2,300,075	$938,905
1899..	21,083	1,512,850	19,840	1,667,135	70	62,400	1,283	131,725	638,213	2,237,080	4,605
1900..	17,764	1,536,320	18,812	1,912,480	71	46,350	1,283	131,180	556,704	2,286,700	739,000
1901..	18,426	1,201,890	19,740	1,725,845	95	45,635	1,310	136,665	627,078	2,545,700	614,700
1902..	14,912	840,410	18,025	1,446,955	45	26,215	1,334	141,155	623,552	2,533,115	734,280

Year.	Stone, All Kinds.		Tin, Unwrought.		Zinc. Ore.		Zinc. Crude.		Zinc. Manufactures.		Metals, Unclassified Wrought & Unwrought.
1898....	27,569	$606,930	5,557	$1,974,430	6,483	$93,365	7,577	$618,875	1,227	$168,695	$3,164,995
1899....	30,728	612,690	4,785	2,937,655	8,171	144,420	5,492	561,460	1,249	207,280	3,559,890
1900....	36,309	770,210	5,713	3,816,700	13,913	207,770	7,136	650,690	1,159	183,605	4,195,940
1901....	47,498	800,105	5,584	3,397,320	13,981	176,580	7,512	542,050	1,256	182,965	4,192,220
1902....	51,672	907,735	6,210	3,678,330	16,717	271,080	6,756	497,475	1,345	187,815	4,313,590

EXPORTS OF FOREIGN AND COLONIAL PRODUCE. (*a*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Chemical Products.	Copper, Unwrought, Partly Wrought, and Old.		Glass. Bottles, *Gross.*		Glass. All Other Kinds		Glass. Total.		Iron, Bar, Angle, Bolt, and Rod.		Steel, Unwrought.	
1898....	$1,509,195	13,454	$3,578,710	12,694	$29,875	3,961	$363,906	$393,780		26,891	$1,135,450	2,619	$154,480
1899....	1,085,185	24,515	9,160,530	13,768	33,840	3,179	257,180	287,095		19,058	879,680	3,289	149,165
1900....	1,178,710	19,168	7,304,960	15,195	52,685	2,544	250,020	302,705		11,116	547,065	2,837	139,870
1901....	2,000,345	23,509	8,171,765	16,830	38,675	2,707	279,545	318,220		12,610	583,165	1,751	127,330
1902....	1,681,965	21,893	5,986,635	15,548	33,350	2,940	316,320	349,670		8,592	364,095	1,142	599,500

Year.	Iron and Steel, N. E. S., Wrought and Manufactured. (*c*)		Petroleum. *Liters.*		Potassium Nitrate.		Quicksilver.		Tin, in Blocks, Ingots, Bars, or Slabs.	
1898.....	29,509	$5,658,860	6,479,451	$217,900	2,775	$303,080	1,157	$1,199,500	15,866	$5,310,350
1899.....	28,874	5,094,890	6,699,181	279,505	1,573	122,940	1,097	1,316,130	17,120	9,953,060
1900.....	.....	4,407,155	7,562,725	354,495	1,581	128,295	880	1,188,705	20,069	13,107,260
1901.....	.....	1,985,865	13,566,754	560,085	1,408	112,640	914	1,194,100	21,271	12,288,135
1902.....	.....	1,306,575	15,587,946	634,490	1,517	123,545	664	838,120	23,344	13,083,560

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Number of tons shipped for the use of steamers engaged in the foreign trade. This not being an export in the ordinary acceptation of the term, the value thereof is not given in the trade returns. (*c*) Including naphtha, paraffine, paraffine oil and petroleum. (*d*) Classified as Soda Compounds in 1901 and 1902. (*e*) N. E. S. signifies "not elsewhere specified."

UNITED STATES.

[illegible] and for parts of the [illegible] production of the United States [illegible] the introduction and the articles on the different substances [illegible] the mineral imports and exports for five years.

MINERAL IMPORTS OF THE UNITED STATES [illegible]

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Year	Value and Metric Equivalent of Value.	Chromite or Lime or Brucite. Lb.	Metric Tons	Value	Value per Met. Ton.	Cement. Barrels.	Metric Tons	Value	Value per Met. Ton
1898	$[illegible]	[illegible]	[illegible]	$[illegible]	$[illegible]	[illegible]	[illegible]	[illegible]	$[illegible]
1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1901	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1902	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

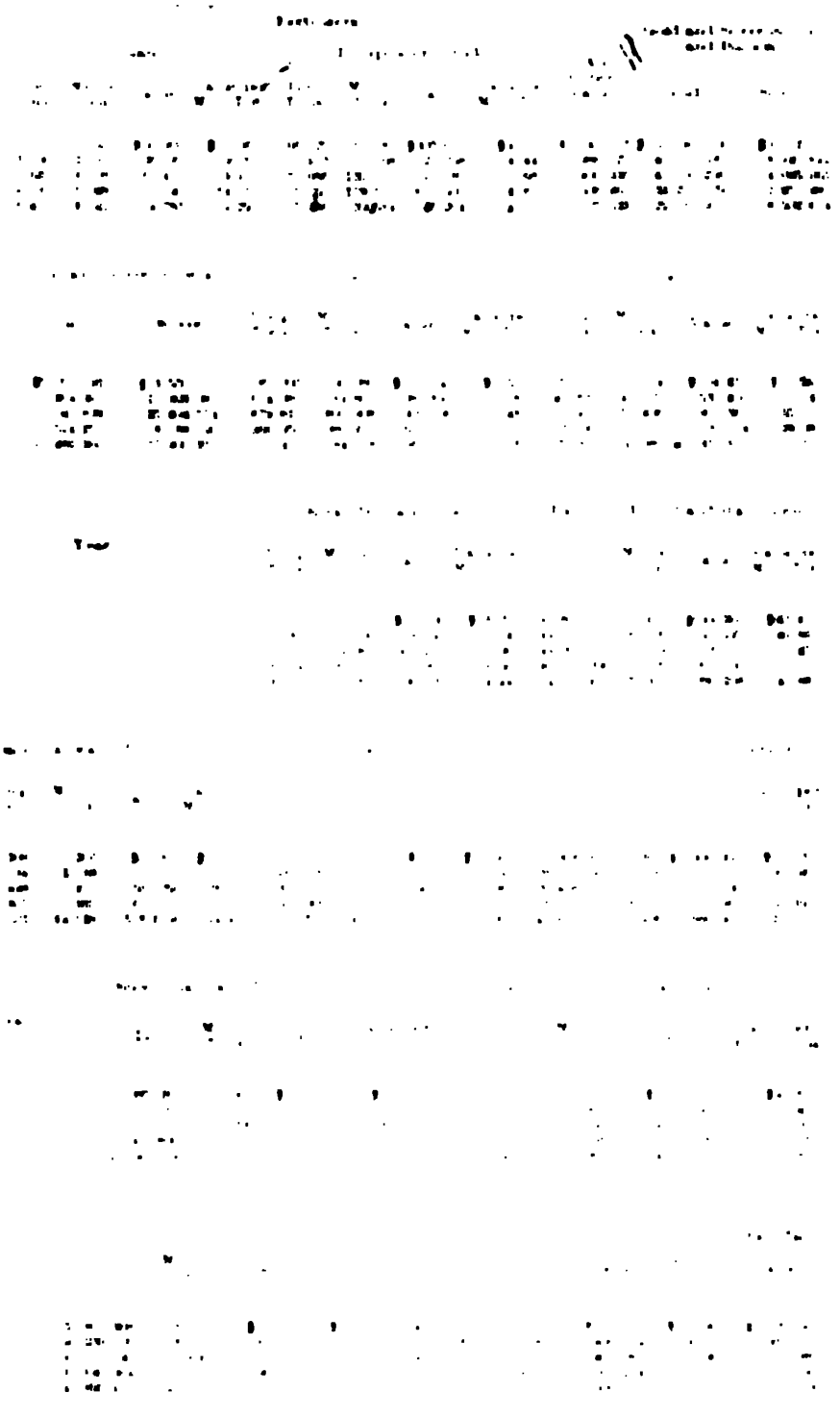
Year	Chromic Iron. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Chromic Acid. Lb.	Kg.	Value.	Value per Kg.	Clays or Earths, including Kaolin. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898	[illegible]	[illegible]	[illegible]	$[illegible]	[illegible]	[illegible]	$[illegible]	$[illegible]	[illegible]	[illegible]	$[illegible]	$[illegible]
1899	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1901	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1902	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Year	Coal. Anthracite. Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Bituminous. Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Total. Metric Tons.	Value.	Value Per Met. Ton.
1898	8,140	8,140	$24,000	$2·69	1,270,557	1,290,698	$3,569,572	$2·77	1,294,085	$3,578,181	$2·77
1899	61	62	245	3·95	1,400,451	1,422,989	3,882,430	2·73	1,422,990	3,882,675	2·73
1900	118	120	549	4·58	1,979,258	1,989,806	5,019,553	2·59	1,989,926	5,020,102	2·59
1901	995	901	1,444	6·34	1,919,992	1,950,081	5,291,429	2·71	1,950,972	5,293,273	2·71
1902	73,000	74,174	222,517	4·76	2,478,375	2,518,029	7,016,274	2·79	2,592,203	7,239,791	2·83

Year	Coke. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Cobalt Oxide. Lb.	Kg.	Value.	Value per Kg.	Copper, Ore and Regulus. Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	41,185	41,844	$142,334	$3·40	$33,731	15,300	$49,345	$3·22	6,861,120	3,112	$654,355	$210·26
1899	97,805	98,301	142,504	5·04	46,791	21,224	68,847	3·24	70,866,880	32,145	2,943,583	65·56
1900	98,175	104,868	371,341	3·54	54,072	24,527	88,651	3·61	121,696,960	55,201	5,195,010	90·76
1901	179,780	73,803	266,078	3·61	71,009	32,645	134,208	4·11	215,133,696	97,584	14,692,645	150·58
1902	107,437	109,150	435,774	3·99	79,944	36,281	151,115	4.16	406,707,840	184,470	8,695,780	47·14

Year.	Copper, Ingots, Old, etc. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Copper, Manufactures, Value.	Copper, Total Value.	Cryolite. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898....	54,106,467	24,570	$4,130,680	$167·71	$39,467	$4,814,502	6,201	6,300	$88,501	$14·05
1899....	71,929,340	32,624	10,189,800	310·80	42,000	12,494,975	5,879	5,973	78,676	13·17
1900....	68,796,808	31,206	10,557,870	338·33	33,390	15,776,870	5,437	5,524	72,783	13·17
1901....	73,896,406	33,498	11,812,216	352·73	24,775	26,589,686	5,263	5,469	70,956	12·96
1902....	103,189,508	46,778	13,051,159	279·17	53,464	21,799,403	6,188	6,287	85,640	13·62

Year.	Earthen, Stone, and China Ware Value.	Emery Grains. Lb.	Metric Tons.	Value.	Value per Met. Ton	Emery Rock. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Emery Manufactures Value.	Emery, Total Value.
1898	$7,973,471	577,633	262	$23,530	$89·01	5,547	5,636	$[illegible]	$[illegible]	$[illegible]	$[illegible]
1899	8,101,033	728,280	330	29,124	88·17	7,435	7,554	[illegible]	[illegible]	[illegible]	[illegible]
1900	9,143,336	661,462	300	26,520	88·39	11,302	11,574	[illegible]	[illegible]	[illegible]	[illegible]
1901	9,816,071	1,116,729	506	43,207	85·37	12,441	12,640	[illegible]	[illegible]	[illegible]	[illegible]
1902	9,888,426	1,665,737	756	60,059	79·47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Year.	Total Value of Iron Imports. (c)	Lead, Pig, Bars, Scrap, and in Ore.				Lead, Sheet, Pipe, Shot, etc.	
		Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.
1898	$12,474,572	179,291,290	81,326	$2,535,362	$31·18	242,759	110
1899	15,800,579	192,877,074	87,498	2,816,788	32·20	110,372	50
1900	20,443,911	228,708,449	103,780	3,957,695	38.13	27,945	13
1901	20,804,995	224,942,329	102 332	4,841,644	47·52	56,735	26
1902	41,468,826	215,282,455	97,629	4,551,516	46·62	224,208	102

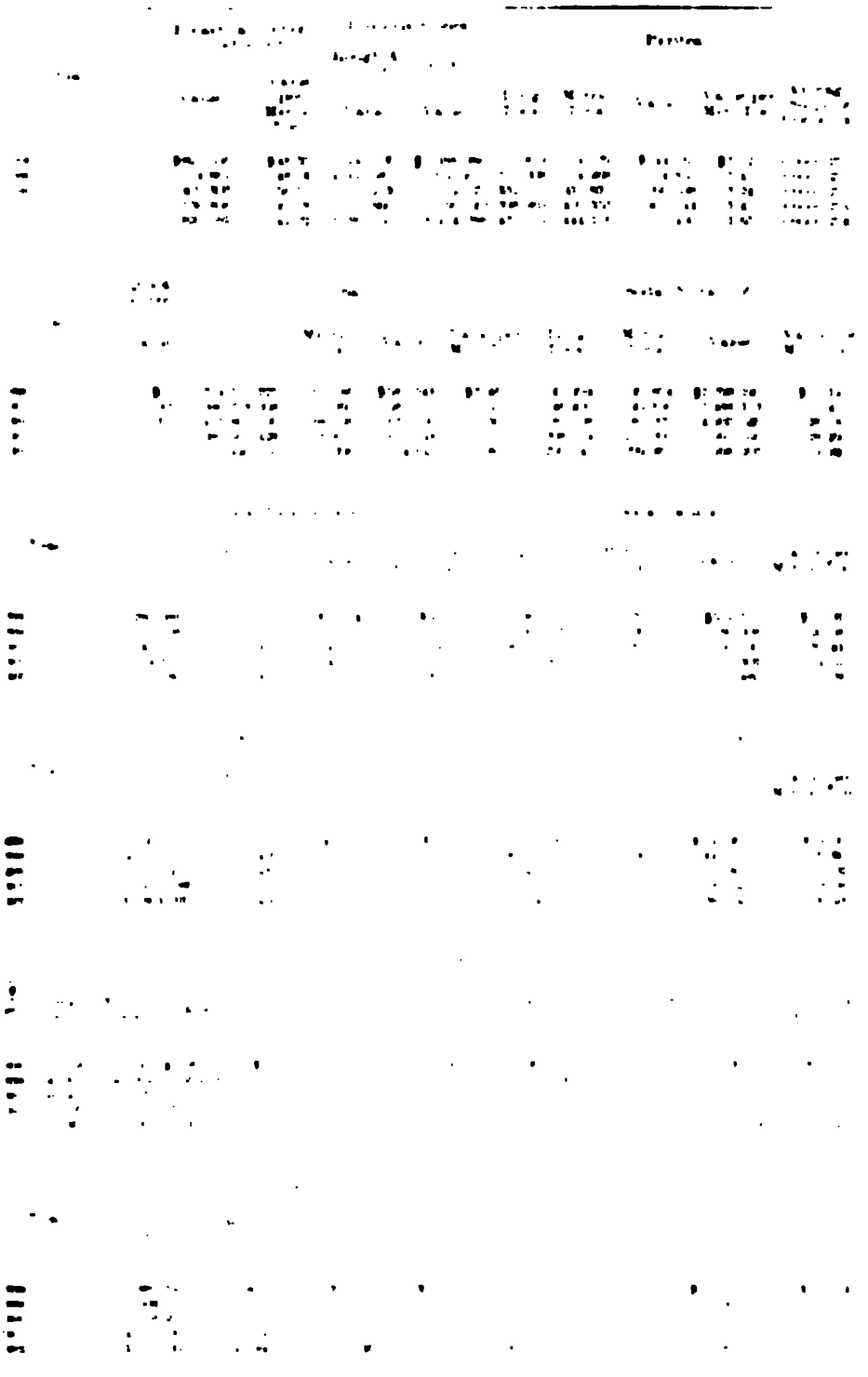
Year.	Lead, Sheet, Pipe, Shot, etc. —Continued.		Lead, Other Manufactures. Value.	Lead, Total Value.	Manganese Ore.			
	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton
1898	$9,399	$ 85·35	*Nil.*	$2,544,751	114,885	116,723	$831,967	$7·13
1899	4,402	74·61	$12,963	2,834,168	188,349	191,363	1,584,528	8·28
1900	1,393	109·68	5,854	3,964,942	256,252	260,352	2,042 361	7·84
1901	2,778	106·65	4,654	4,849.071	165,720	168,372	1,486,573	8·83
1902	7,765	76·18	18,918	4,578.199	235,576	239,345	1,931,282	8·07

Year.	Marble and Stone, and M'f'res of.			Metals, Metal Compositions, and Manufactures of, N.E.S.			Mica, Mineral Substances, and Nickel.		
	Marble and Manufactures of.	Stone and Manufactures of.	Total.	Bronze Manufactures.	All Other.	Total.	Mica.	Mineral Substances N. E. S.	Nickel.
	Value.	Value. (d)	Value.	Value.	Value.	Value.	Value.	Value.	Value.
1898	726,343	$229,909	$956,252	$508,814	$3,479,221	$3,988,035	$150,062	$19,160	(f)
1899	726,070	200,192	926,262	710,086	4,008,942	4,719,028	275,984	78,453	(f)
1900	945,705	256,024	1,202,329	791,306	5,420,483	6,211,789	319,560	71,377	(f)
1901	1,226,524	237,191	1,463.715	945,702	5,162,392	6,108,094	335.054	109,049	$1,657,168
1902	1,486,454	222,438	1,657,892	816,668	5,942,017	6,758,685	466,332	119,849	1,156,372

Year.	Oil, Mineral.				Paints, Mineral. Zinc Oxide in Oil.				Paints and Colors.	Platinum, Man'f'ur'd.
	Gallons.	Liters.	Value.	Value per Liter.	Lb.	Metric Tons.	Value.	Value pr. Met. Ton.	Value.	Value.
1898	2,094,090	7,661,808	$146,713	$·019	27,050	12	$2,279	$189·92	$1,142,670	$271
1899	1,107,077	4,190,030	103,047	·025	41,699	19	4,154	219·79	1,412,877	876
1900	3,039,094	11,508,913	274,766	·024	38,706	18	3,098	176·02	1,491,902	827
1901	2,294,084	8,686,389	151,913	·018	128,198	58	8,963	154·88	1,524,125	2,513
1902	4,274,022	16,181,325	247,153	·015	163,081	74	11,534	155·86	1,744,971	2,705

Year.	Platinum, Unmanufactured.			Plat'm Vases, Retorts	Potash, Chlorate of.				Potash, Chromate & Bichromate.			
	Kg.	Value.	Val. per Kg.	Value.	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.
1898	3,142·07	$1,178,142	$374·96	$52,012	4,805,332	2,180	$288,965	$132·55	1,160,710	526	$36,134	$163·73
1899	3,041·32	1,482,157	487·34	54,877	1,534,657	696	102,189	146·82	1,130,965	513	73,510	143·29
1900	3,450·06	1,738,777	501·81	35,887	1,243.612	564	68,772	121·94	111.761	51	7,758	153·02
1901	3,706·90	1,673,718	598·42	21,989	811.127	368	61,348	166·71	430,996	195	29.234	149·86
1902	3,234·60	1,950,362	602.97	34,913	1,209,148	548	60,429	110·27	231,009	105	15.161	144·39

Year.	Potash, Muriate of.				Potash, Nitrate of.				Potash, all other.	
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.
1898	103,368,701	46,888	$1,620,720	$34·57	11,461,823	5,199	$281,504	$54·15	37,736,761	17,117
1899	117,449,708	53,275	1,819,448	34·15	18,961,270	8,601	377,371	43·88	46,453,415	21,071
1900	130,175,481	59,047	1,976,604	33·48	10,545,392	4,783	276,684	57·84	54,904,988	24,904
1901	148,189,337	65,404	2,316,577	35·39	9,656,398	4,380	253,296	57·81	72,428,913	32,853
1902	140,980,460	63,947	2,141,553	33·49	10,505,474	4,765	299,436	62·84	92,257,039	41,119



Year	Zinc. Block, Pig, and Old. Lb.	Metric Tons	Value.	Value per Met. Ton.	Manufactures of. Net Value.	Total Value.
1898	2,702,257	1,244	$169,924	$99·12	$13,445	$183,672
1899	2,596,493	1,264	151,266	112·23	14,990	166,256
1900	2,013,126	913	97,772	107·05	36,826	134,598
1901	775,991	352	30,929	87·94	42,648	73,588
1902	1,992,206	736	46,236	62·15	40,883	87,619

(a) From Summary of Commerce and Finance of the United States. (b) Custom-house returns for these years are given in pounds, which are reduced to tonnes of 40 Bu. for convenience of comparison. (c) Including slags, etc. (d) Not including ore. (e) Not reported. (g) Includes lactic acid.

MINERAL EXPORTS OF DOMESTIC PRODUCTION OF THE UNITED STATES. (a)

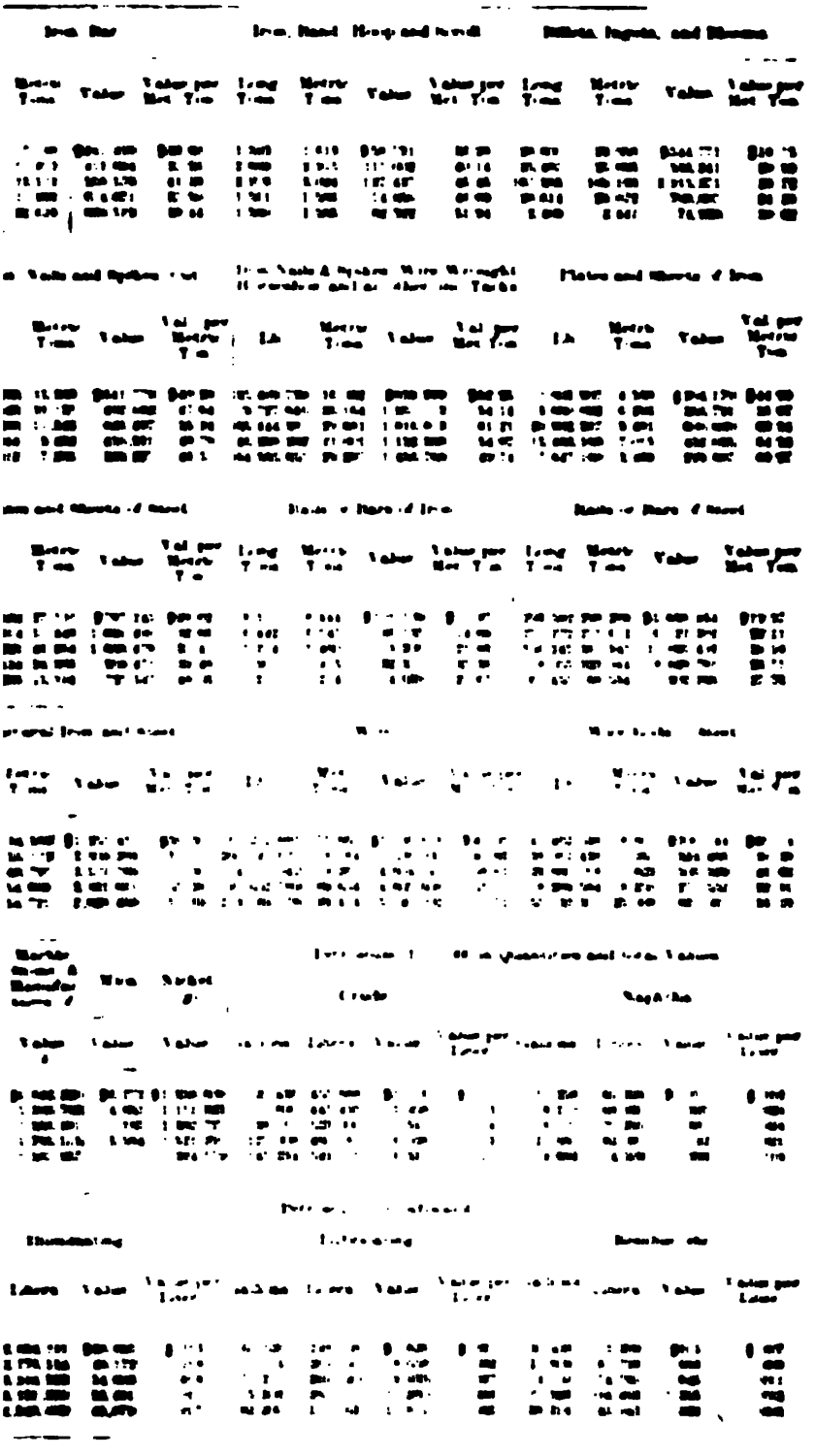
Year.	Aluminum and Manufactures of. Value.	Asbestos. Value.	Brass & Manufactures of. Value.	Cement. Bbls.	Metric Tons(m)	Value.	Value per Met. Ton.	Chemicals, Drugs and Medicines. Value.	Coal. Anthracite. Long Tons.	Metric Tons.
1898	$(g)99,907	$64,660	$1,237,027	26,732	6,665	$73,338	$11·08	$9,732,734	1,350,948	1,372,568
1899	991,515	77,409	1,607,072	81,090	14,713	166,073	11·29	11,949,834	1,707,796	1,735,121
1900	991,921	124,971	2,098,072	100,400	18,216	225,206	12·37	13,771,682	1,654,610	1,681,084
1901	1,166,579	118,316	2,078,178	378,934	67,903	679,296	10·79	14,267,110	1,998,207	2,035,300
1902	116,052	130,437	1,900,312	340,821	61,838	526,471	8.51	13,437,867	907,977	922,505

Year	Coal.—Continued. Anthracite.—Con. Value.	Val. per Met. Ton.	Bituminous. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Total Long Tons.	Total Metric Tons.	Total Value.	Copper Ore. (c) Lb.	Metric Tons.
1898	$6,712,980	$4·16	3,152,157	3,202,806	$6,699,248	$2·09	4,503,105	4,575,459	$12,412,233	20,928,390	9,492
1899	7,140,100	4·19	4,044,954	4,109,064	8,573,276	2·09	5,752,150	5,844,184	15,713,376	8,393,280	3,807
1900	7,080,480	4·29	6,302,100	6,403,031	14,431,590	2·27	7,917,519	8,043,996	21,524,079	22,415,040	10,168
1901	8,017,147	4·41	5,800,080	5,893,827	13,065,763	2·49	7,383,808	7,501,527	22,092,910	43,983,120	19,957
1902	4,801,040	4·00	5,218,080	5,302,472	13,927,063	2·62	6,126,946	6,224,977	18,229,009	40,398,400	18,324

Year.	Copper Ore.—Con. (c) Value.	Val. per Metric Ton.	Copper, Pig, Sheet, and Old. Lb.	Metric Tons.	Value.	Val. per Met. Ton.	Copper. Manufactures. Value.	Copper. Total Value.	Earthen, and China Ware. Value.
1898	$755,443	$79·59	291,055,005	132,480	$38,598,869	$283·71	$1,190,989	$35,545,251	$251,821
1899	442,808	116·32	246,826,331	111,900	41,190,987	367·90	1,852,499	43,485,654	511,732
1900	1,332,920	131·08	337,973,751	153,304	55,285,047	360·51	2,357,563	58,875,439	558,794
1901	2,530,540	127·30	194,949,828	88,111	31,602,563	359·70	1,842,336	36,077,448	586,830
1902	1,508,181	79·37	254,698,840	160,876	43,392,800	269·73	2,093,798	46,811,729	604,646

Year	Fertilizers. Phosphates, Crude. Long Tons.	Metric Tons.	Value.	Value per Met. Tons.	All Other. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Glassware. Value.	Gold and Silver in Coin and Bullion. (e) Gold.	Silver.
1898	370,848	376,883	$4,672,463	$8·05	16,714	16,981	$442,977	$26·09	$1,398,919	$16,113,258	$33,673,605
1899	867,740	881,675	6,770,102	7·68	49,082	49,867	1,031,892	20·69	1,716,943	45,537,661	52,452,562
1900	610,925	620,913	5,217,560	8·35	25,976	26,392	537,976	20·38	2,042,633	34,864,687	65,705,919
1901	730,339	741,912	5,859,243	7·88	14,153	14,379	332,984	23·17	2,057,963	36,737,350	55,395,875
1902	802,698	814,919	6,193,372	7·60	16,431	16,714	383,438	22·94	2,694,702	35,722,535	45,29·,·18

Year.	Gold and Silver in Ores. (f) Gold	Silver	Iron Ore. Long Tons.	Metric Tons.	Value	Value per Met. Ton	Iron. Pig. Long Tons.	Metric Tons.	Value.	Value per Met. Ton
1898	$[illegible]	$[illegible]	31,579	32,084	$[illegible]	$[illegible]	[illegible]	[illegible]	$[illegible]	$[illegible]
1899	[illegible]	[illegible]	40,693	41,316	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1900	[illegible]	[illegible]	51,860	52,678	154,734	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1901	3,012,300	[illegible]	64,708	65,746	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1902	807,736	44,931	86,443	87,800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Petroleum. Concluded.

Year.	Paraffine.				Quicksilver.				Tin Manufactures. Value.
	Lb.	Metric Tons	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	
1898	166,317	75·4	$6,703	$94·34	991,697	445	$446,537	$1004·0	$591,704
1899	181,961	82·5	7,920	92·74	1,274,372	573	960,546	1,682·32	401,217
1900	157,108	71·2	8,195	114·95	776,191	353	425,642	1,206·61	467,354
1901	151,925	68·8	7,990	115·70	843,989	382	475,000	1,241·79	485,035
1902	176,270	79·5	8,304	105·64	1,013,434	459	575,000	1,252·94	529,061

Year.	Zinc Ore.				Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value Per Metric Ton.
1898	23,594,000	10,699	$299,870	$28·05	7,849,059	3,560	$252,194	$70·83
1899	55,441,200	25,150	725,944	28·86	10,695,226	4,847	366,598	75·64
1900	84,123,200	38,158	1,123,663	29·71	11,391,606	5,167	496,380	96·06
1901	88,312,000	40,056	1,167,694	29·15	9,122,298	4,138	398,259	96·08
1902	109,226,000	49,542	1,449,104	29·25	10,716,364	4,861	433,722	89·22

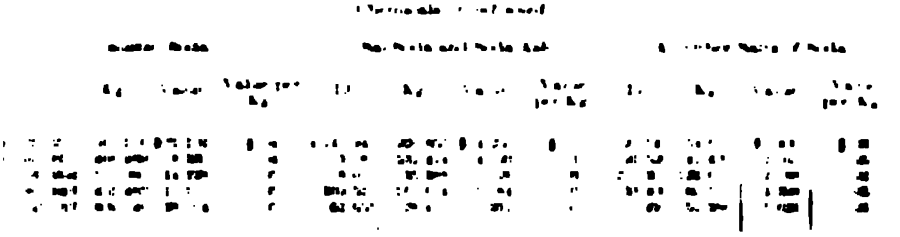
Year.	Zinc; Pigs, Bars, Plates and Sheets.				All Other Manufactures. Value.	Total Value.
	Lb.	Metric Tons.	Value.	Value per Met. Ton.		
1898	20,998,413	9,525	$1,063,959	$108·55	$138,165	$1,734,188
1899	13,509,316	6,128	742,521	121·17	143,292	1,978,356
1900	44,892,577	20,362	2,217,693	109·13	99,288	3,947,084
1901	6,780,221	3,071	288,906	94·08	82,046	1,031,865
1902	6,478,135	2,938	300,557	102·37	114,197	2,297,590

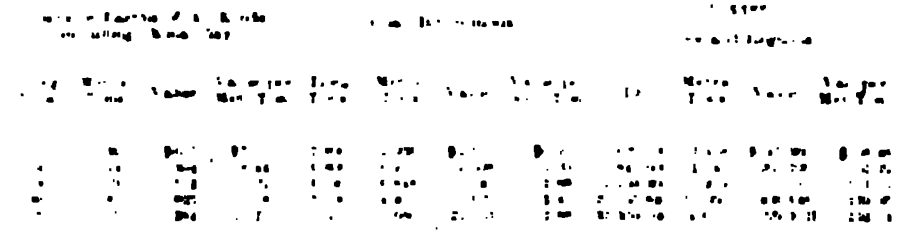
MINERAL EXPORTS OF FOREIGN PRODUCE FROM THE UNITED STATES. (*a*)

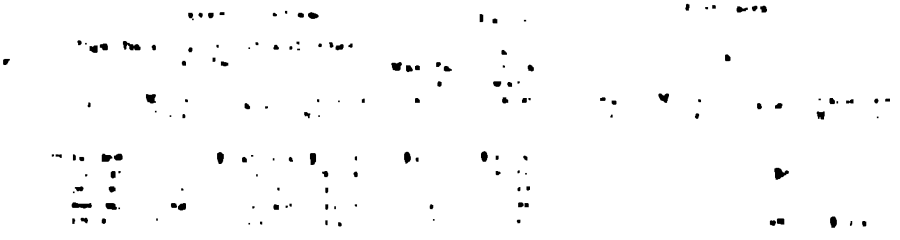
Year.	Antimony.				Antimony Ore.			
	Lb.	Metric Tons.	Value.	Value Per Metric Ton.	Lb.	Metric Tons.	Value.	Value Per Metric Ton.
1898	26,275	11·4	$1,729	$151·67	34,321	15·6	$784	$50·25
1899	16,815	7·6	1,275	167·76	*Nil.*			
1900	23,530	10·7	2,352	219·81	*Nil.*			
1901	*Nil.*	*Nil.*	*Nil.*	*Nil.*	49,655	22·1	1,536	69·50
1902	37,184	16·9	2,710	160·35	808,531	94·6	4,602	48·64

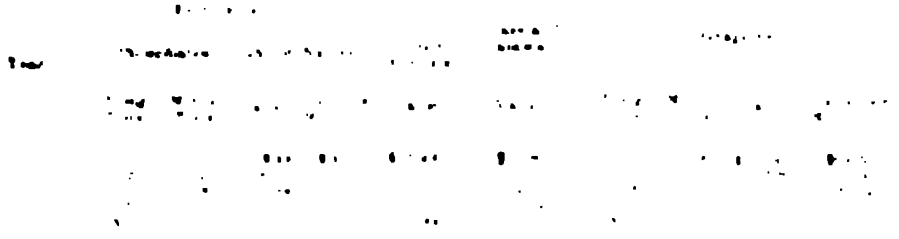
Year.	Asphaltum or Bitumen (Crude.)				Brass and Manufactures of. Value.	Cement.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.		Lb.	Metric Tons.	Value.	Value per Met. Ton
1898	1,514	1,538	$28,606	$18·64	$1,080	6,574,858	2,982	$24,253	$8·14
1899	1,104	1,213	24,486	20·19	766	11,672,694	5,295	47,394	8·95
1900	639	649	10,044	15·73	2,155	15,815,851	7,174	63,440	8·90
1901	2,300	2,244	18,078	8·06	813	17,476,590	7,927	72,797	9·18
1902	3,930	3,977	23,564	7·98	988	13,037,564	5,913	48,797	8·25

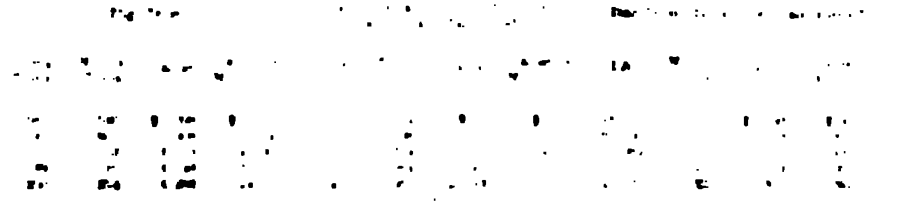
Year.	Chemicals.											
	Salts of Potash. (*b*)				Chloride of Lime.				Nitrate of Soda.			
	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.
1898	183,804	82,466	$5,444	$·07	28,605	12,975	$381	$·03	1,646,[illegible]	746,[illegible]	$[illegible]	$·[illegible]
1899	402,230	182,430	12,594	·07	*Nil.*				3,310,[illegible]	1,[illegible]	[illegible]	[illegible]
1900	848,701	385,024	43,324	·12	148,116	67,185	1,987	·03	[illegible]	[illegible]	[illegible]	[illegible]
1901	633,100	287,182	43,446	·15	13,916	6,312	312	·05	[illegible]	[illegible]	[illegible]	[illegible]
1902	1,266,125	574,310	50,730	·14	198,794	90,172	2,385	·03	[illegible]	[illegible]	[illegible]	[illegible]











Year.	Iron and Steel, and Tin Plate.—Continued.											
	Railway Bars of Iron or Steel, or in Part of Steel.				Ingots, Blooms, Slabs, Billets and Bars of Steel, and Steel in Forms, N. E. S.			Sheet, Plate and Taggers. Wire Rod, Wire, and Wire Rope and Strand, Iron or Steel.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	140	142	$3,479	$24·50	199,417	46	$3,929	$48·24	824,733	374	$21,231	$56·77
1899	*Nil*	.....	.....	.....	10,769	5	1,718	350·61	377,402	171	11,149	65·12
1900	*Nil.*	.....	.....	.....	5,349	2	1,342	559·17	469,790	213	11,599	54·56
1901	*Nil.*	.....	.....	.....	4,042	2	1,059	494·58	426,077	193	17,272	89·48
1902	207	201	23,87	7·184	236,809	170	6,774	39·85	523,593	240	14,221	59·25

Year.	Iron and Steel, and Tin Plate—Concluded.					Lead and Manufactures of. Value.	Marble and Stone and Manufactures of. Value. (k)	Metal Compositions and Manufactures. Value.
	Tin Plates, Terne Plates, and Taggers Tin.				Manufactures. Value.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.				
1898	999,757	408	$22,271	$54·59	$279,717	$2,599,734	$5,452	$58,810
1899	378,866	172	11,308	65·82	346,795	2,881,641	7,525	57,660
1900	1,039,604	471	37,305	79·39	328,704	3,843,661	5,721	79,216
1901	264,359	120	8,519	70·99	149,771	4,190,525	17,063	35,638
1902	219,681	99	7,471	75·45	242,225	3,553,144	11,210	108,831

Year.	Oil, Mineral.				Paints and Colors. Value.	Precious Stones. Value.	Salt.			
	Gallons.	Liters.	Value.	Value per Liter.			Lb.	Met. Tons.	Value.	Value per M. Ton.
1898	3,210	12,185	$486	$0·04	$15,654	$39,974	4,827,288	2,189	$4,751	$2·17
1899	150	568	38	·07	12,104	49,256	5,216,112	2,366	9,858	4·17
1900	4,708	17,814	800	·04	13,814	14,189	3,548,724	1,610	3,907	2·43
1901	1,475	5,584	831	·15	17,923	32,607	3,699,411	1,678	7,155	4·26
1902	2,000	7,572	210	·03	14,217	*Nil.*	2,043,459	927	4,544	4·89

Year.	Sulphur or Brimstone (Crude).				Tin, in Bars, Blocks, Pigs, Grain or Granulated.				Zinc and M'f'res
	Long Tons.	Met. Tons.	Value.	Value per M. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Value.
1898	1,414	1,437	$31,822	$22·14	740,326	336	$113,334	$337·30	$1,538
1899	477	485	10,804	22·29	999,315	453	265,188	585·02	1,604
1900	500	500	13,495	22·53	1,108,124	503	335,377	667·28	3,048
1901	207	210	5,086	24·22	2,103,723	954	562,350	589·46	1,541
1902	1,953	1,973	28,024	22·01	1,071,921	448	266,897	590·13	765

(a) From *Summary of Commerce and Finance of the United States.*
(c) Ore, so called, consisting chiefly of matte.
(e) Total exports of coin and bullion; that is, includes both domestic and foreign not elsewhere specified.
(f) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte which is classified as copper ore and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin.
(g) Including nickel oxide and matte.
(h) Includes chlorate, muriate, and nitrate of potash, and all other salts of potash.
(j) Reported in bbls. and reduced to gals. at 42 gals. = 1 bbl.
(k) Including slate.
(m) Calculated at 1 bbl. = 400 lb.
(n) Not enumerated.
(o) Not reported separately. Included with crude phosphates.
(p) Not reported separately. Included with antimony.
NOTE.—N. E. S. signifies not elsewhere specified.

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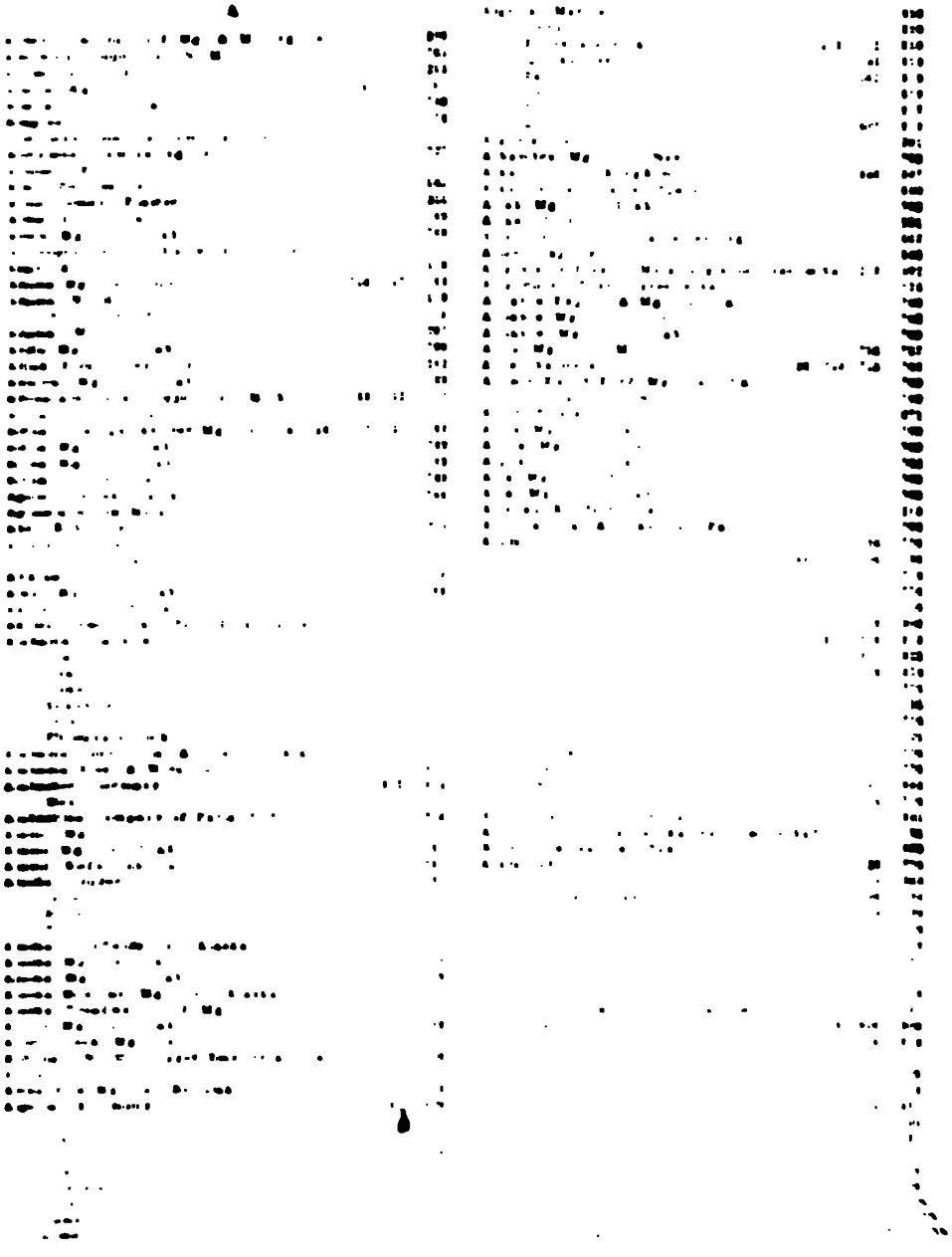

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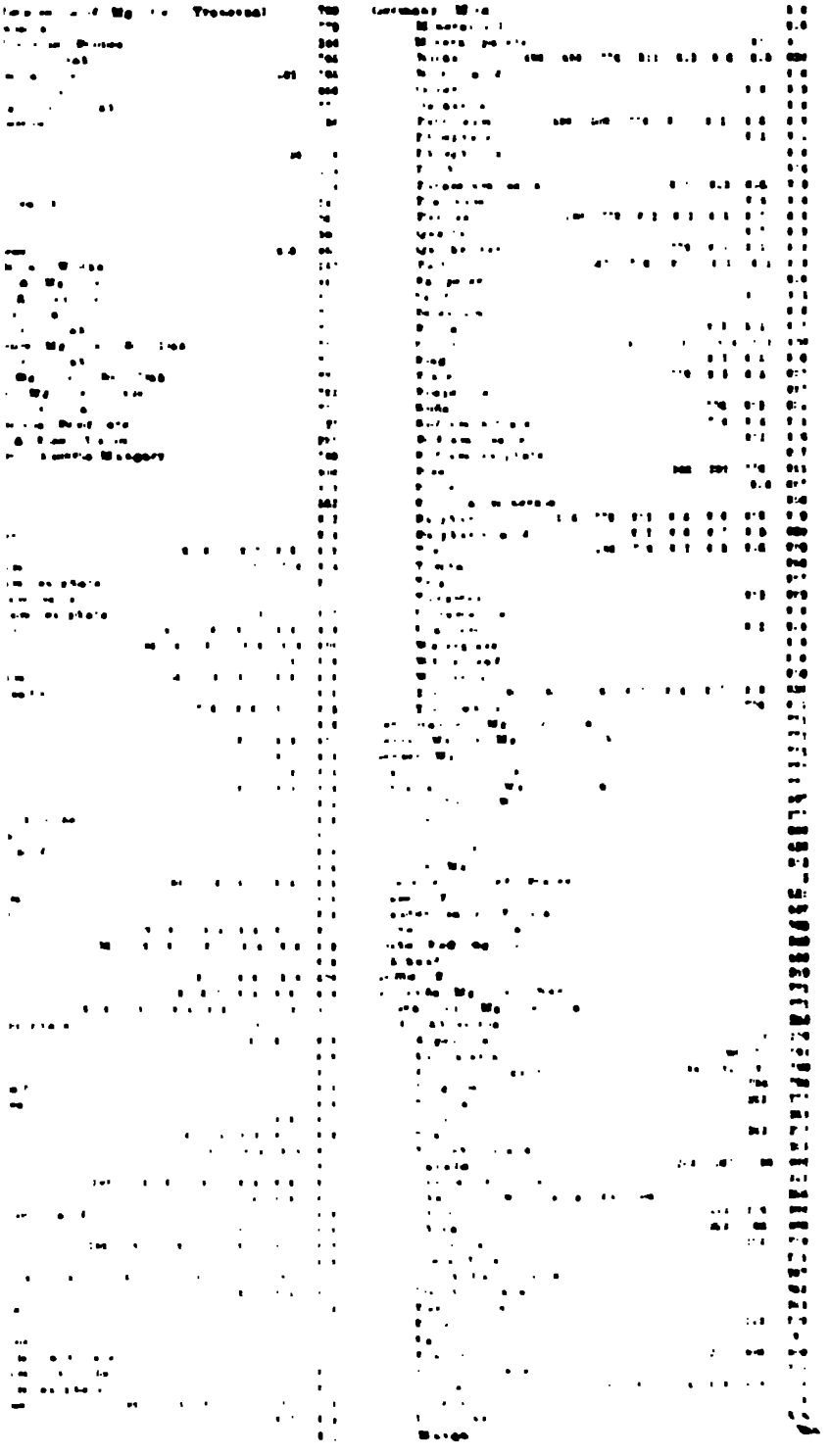

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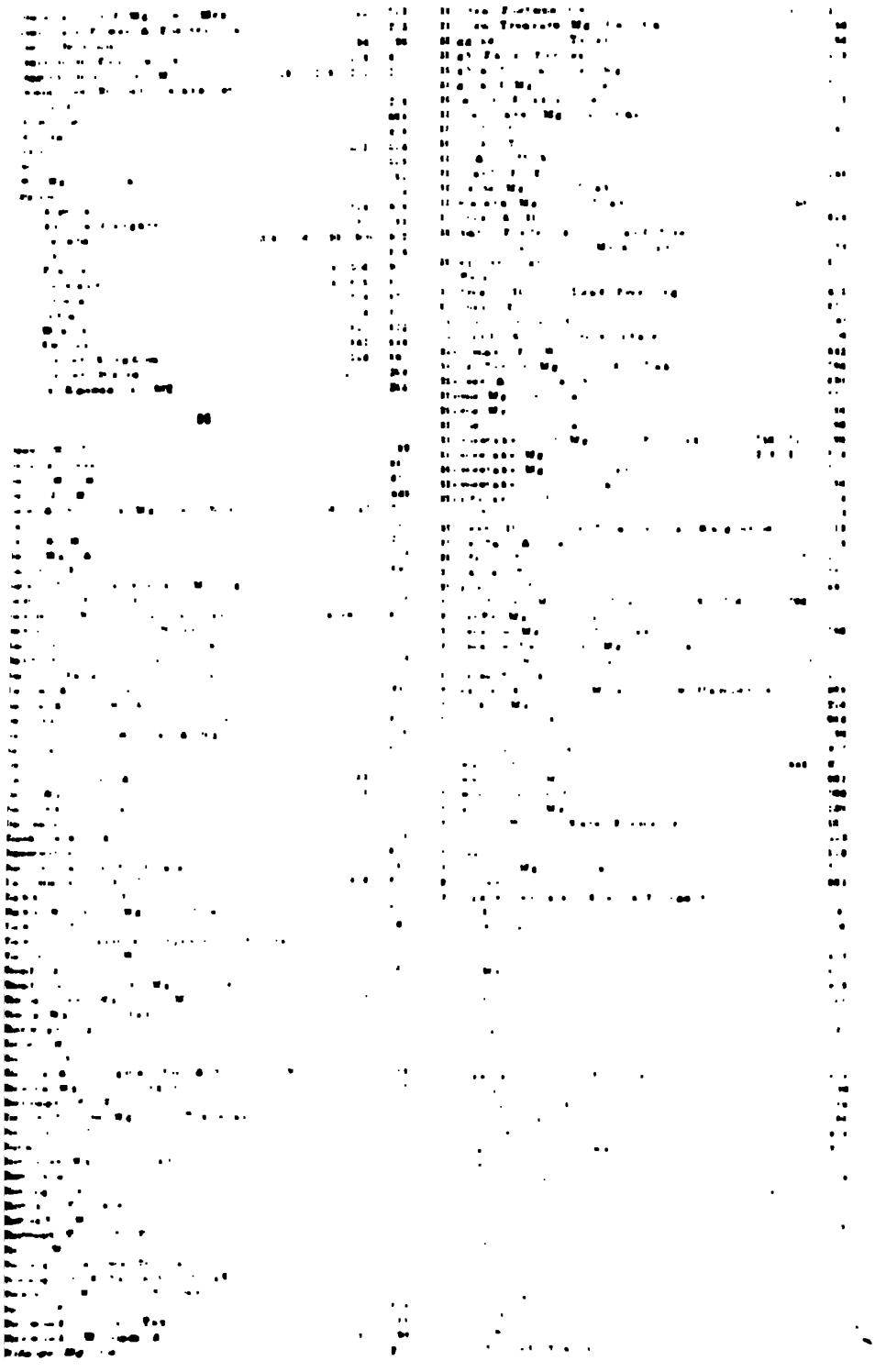

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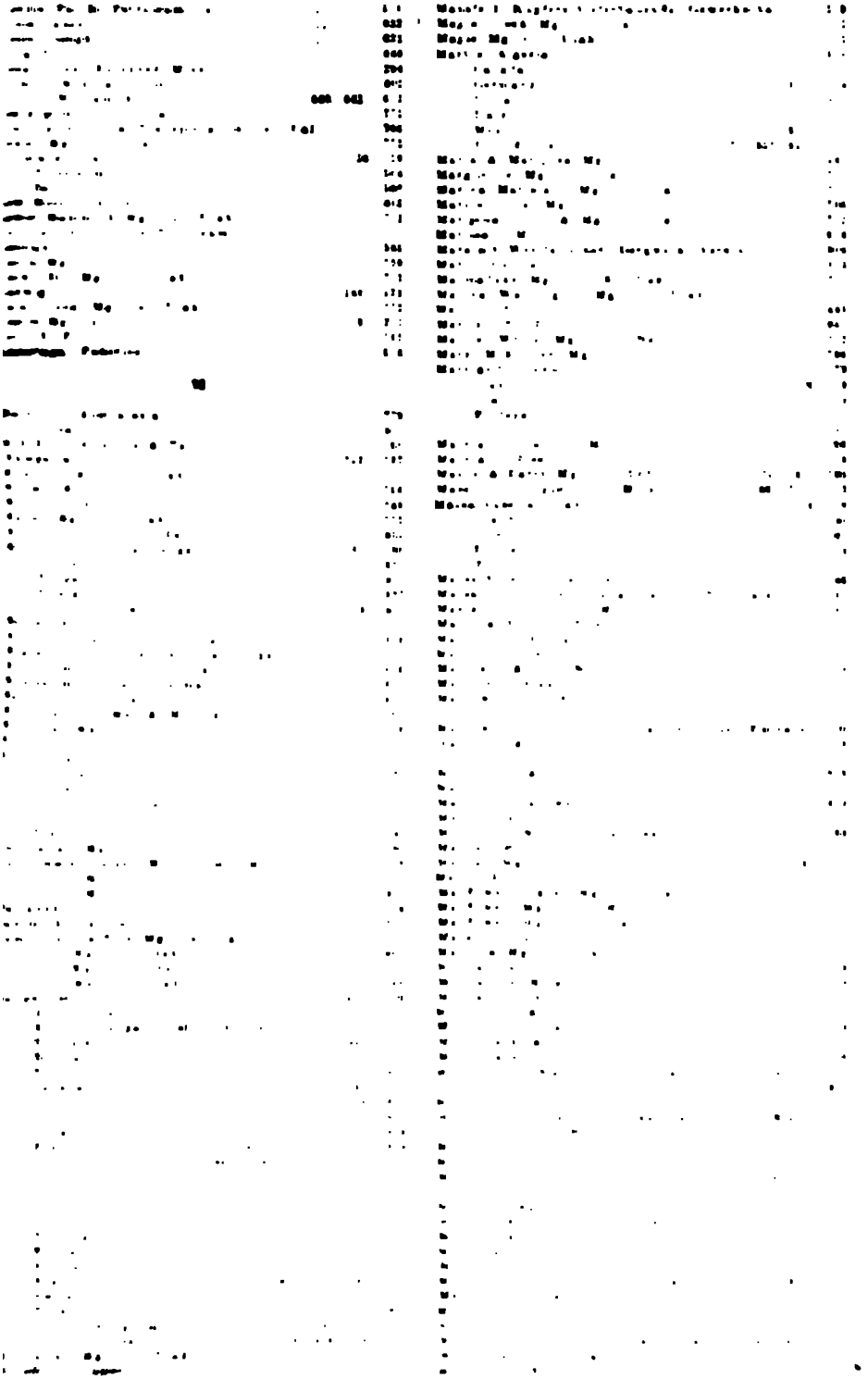

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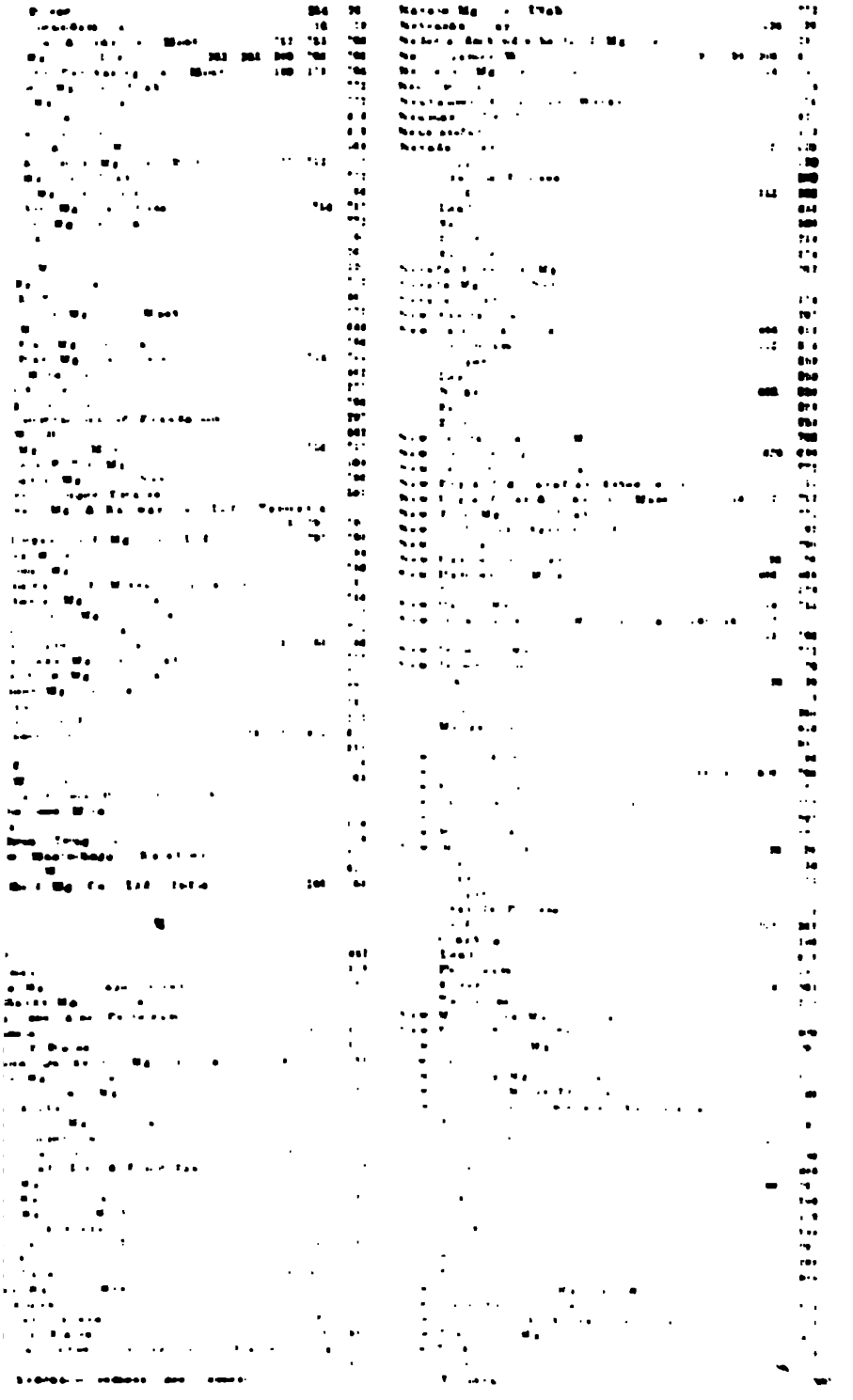

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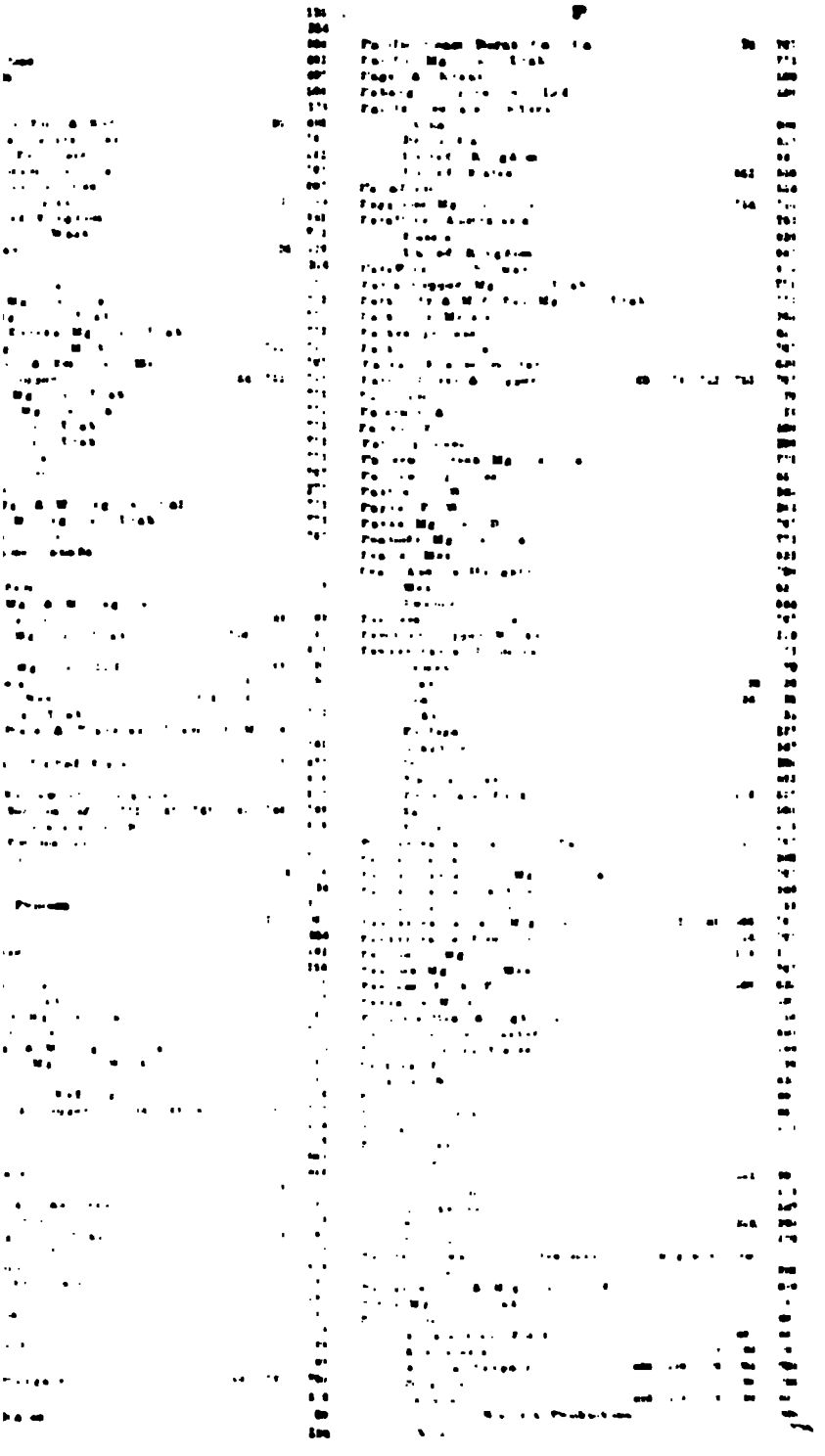

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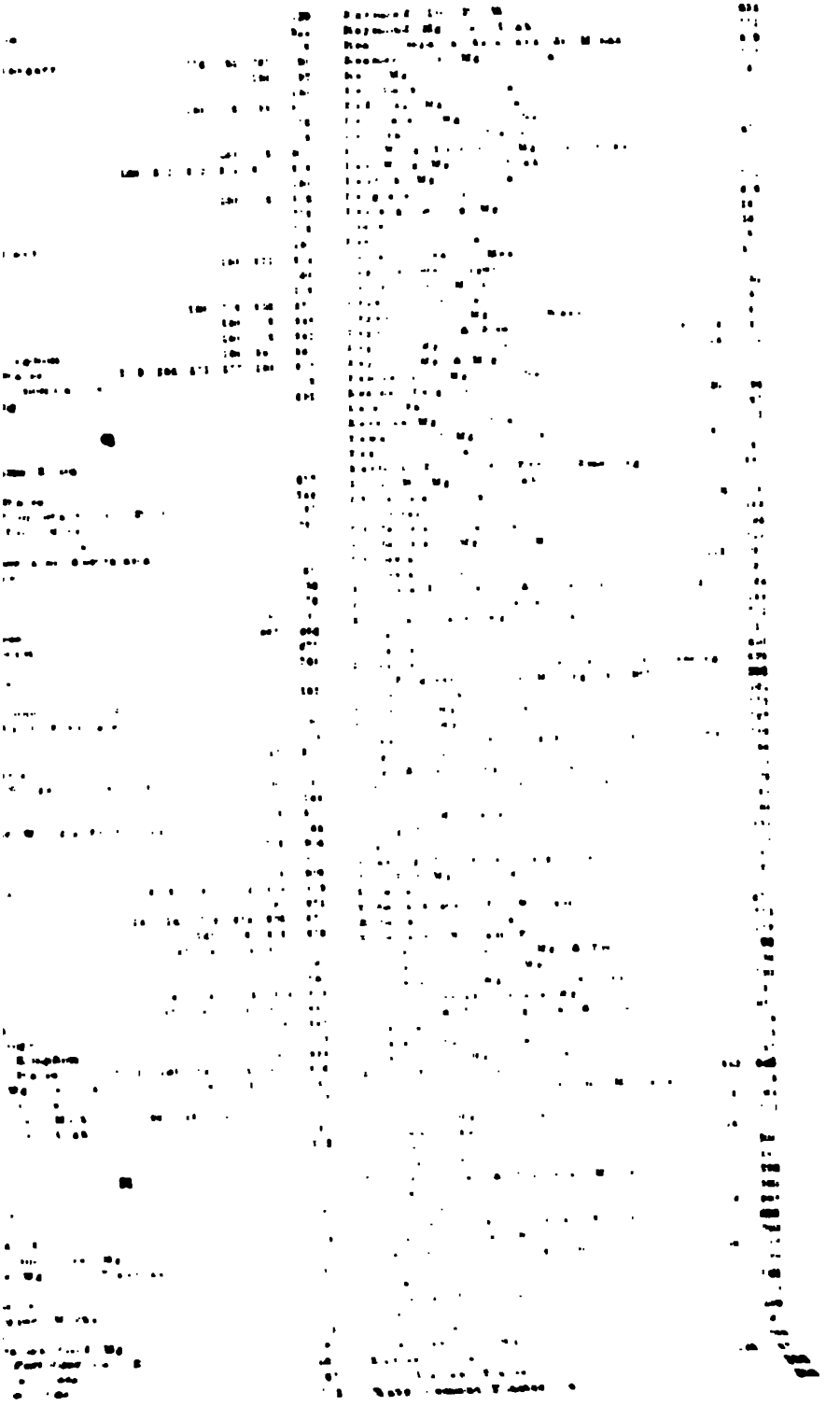

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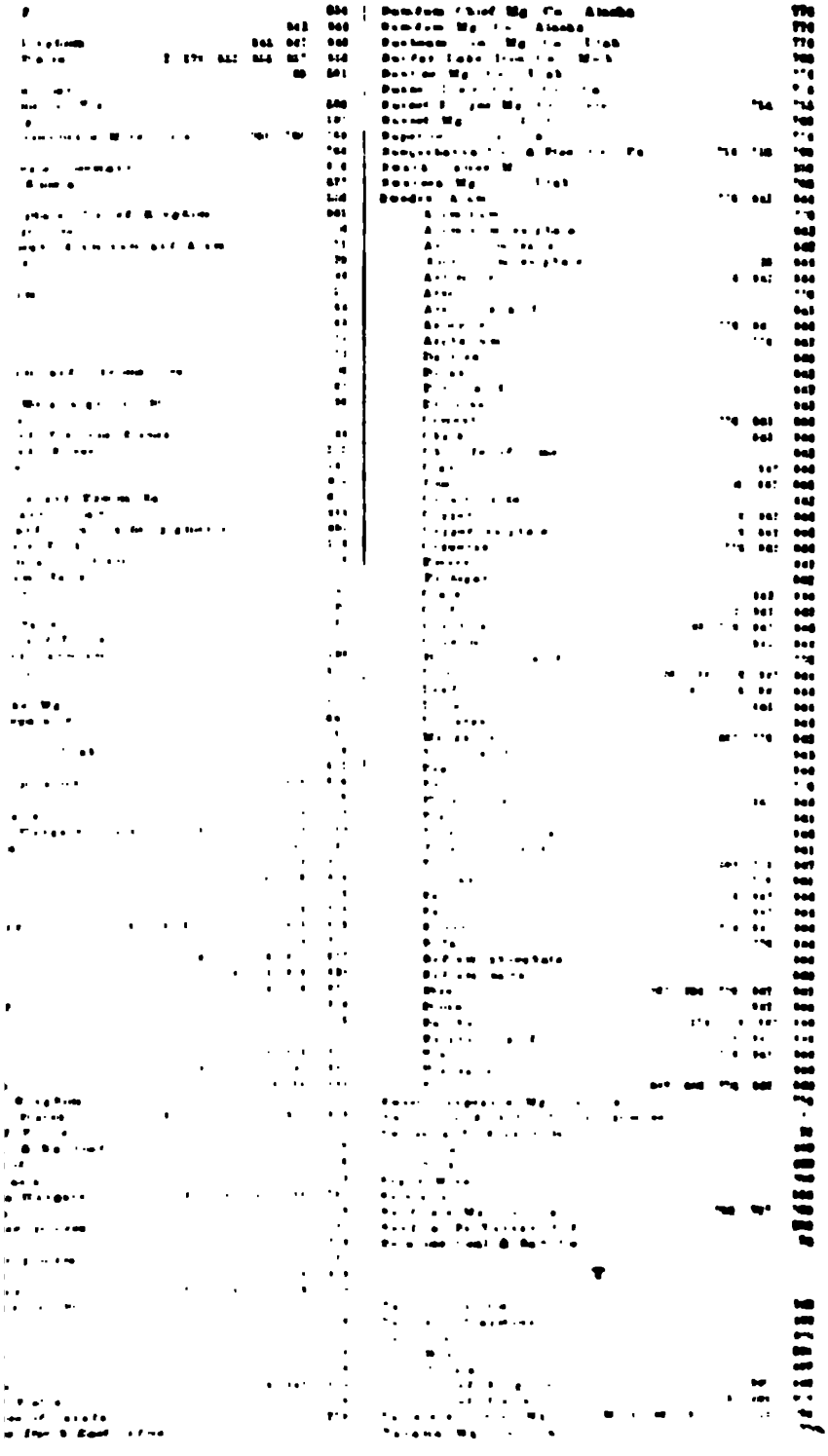

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The
Buyers'
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Preface.

THE advertising pages of the annual volumes of this work will well repay the careful perusal and study of every reader who wishes to be well informed upon the present condition of the mineral industry. They give an admirable and practical insight into the present state of the mining and metallurgic arts, for in them nearly every manufacturer or dealer of note in this country advertises the machines, appliances, and processes which are now in vogue, or which it is sought to introduce; while the names and specialties of the most eminent members of the engineering professions, as indicated in their cards, show the direction of modern mining and metallurgical progress.

These advertising pages are no less important to those who desire a clear knowledge of the means by which this country has come to be far the most important producer of minerals and metals than to those who wish to know where to get that full and reliable information concerning the values of properties, machinery, processes, and products which should precede the investment of capital.

Every country in the world is wisely striving to develop its mineral resources, and to build up its mineral industry, and in all of them this volume, which gives the latest and best practice in every department of the industry, has become indispensable. It is constantly consulted for the best technical skill and the most advantageous machinery and appliances in use. All enterprising manufacturers of such wares appreciate this fact, and know that in no other way can they so effectively bring their goods before those who may need them as through the advertising pages of THE MINERAL INDUSTRY. These pages have become a veritable directory of the best in everything relating to the industry, and American, German and English manufacturers there compete for the orders of the whole world. $1,000,000,000 a year is certainly not an overestimate of the annual expenditure for technical skill, machinery and supplies used in the industry of which THE MINERAL INDUSTRY and *The Engineering and Mining Journal* are not only the chief but the only universal representatives published in any language.

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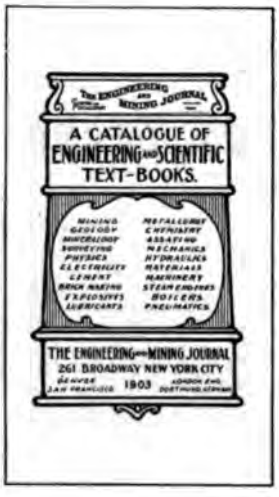

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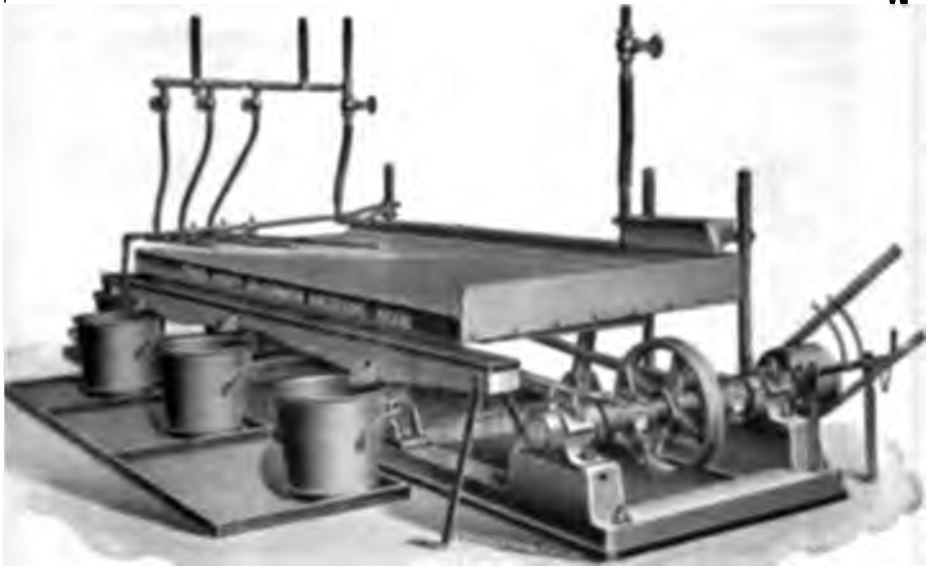

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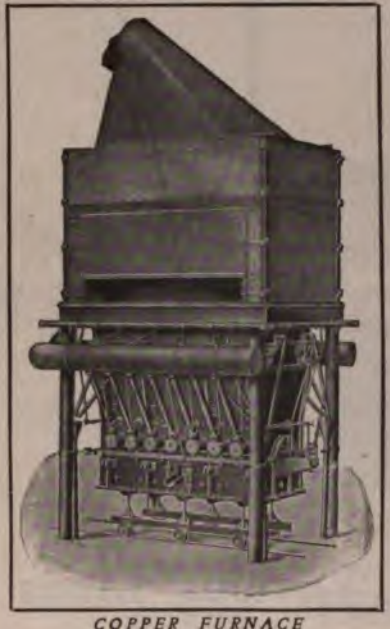

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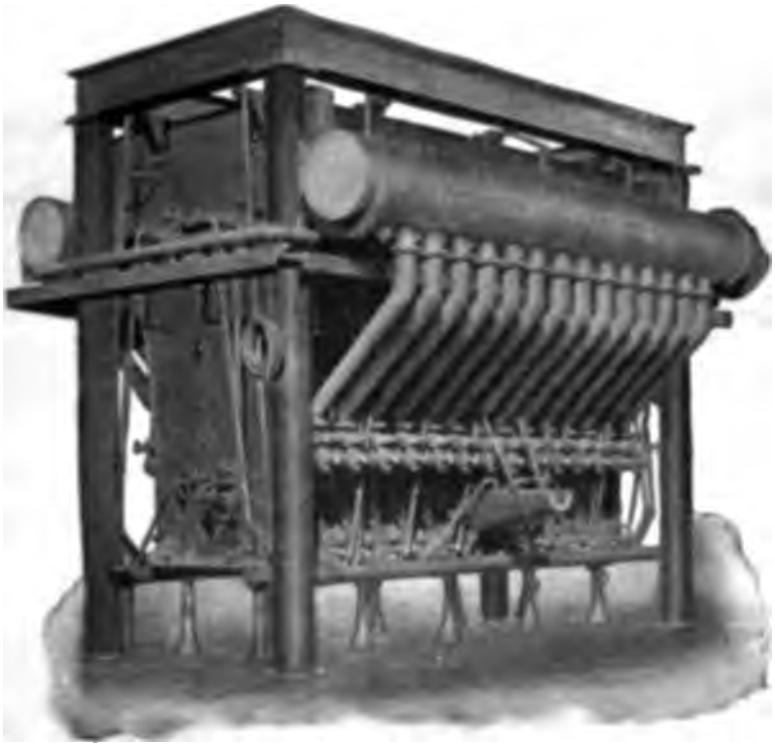

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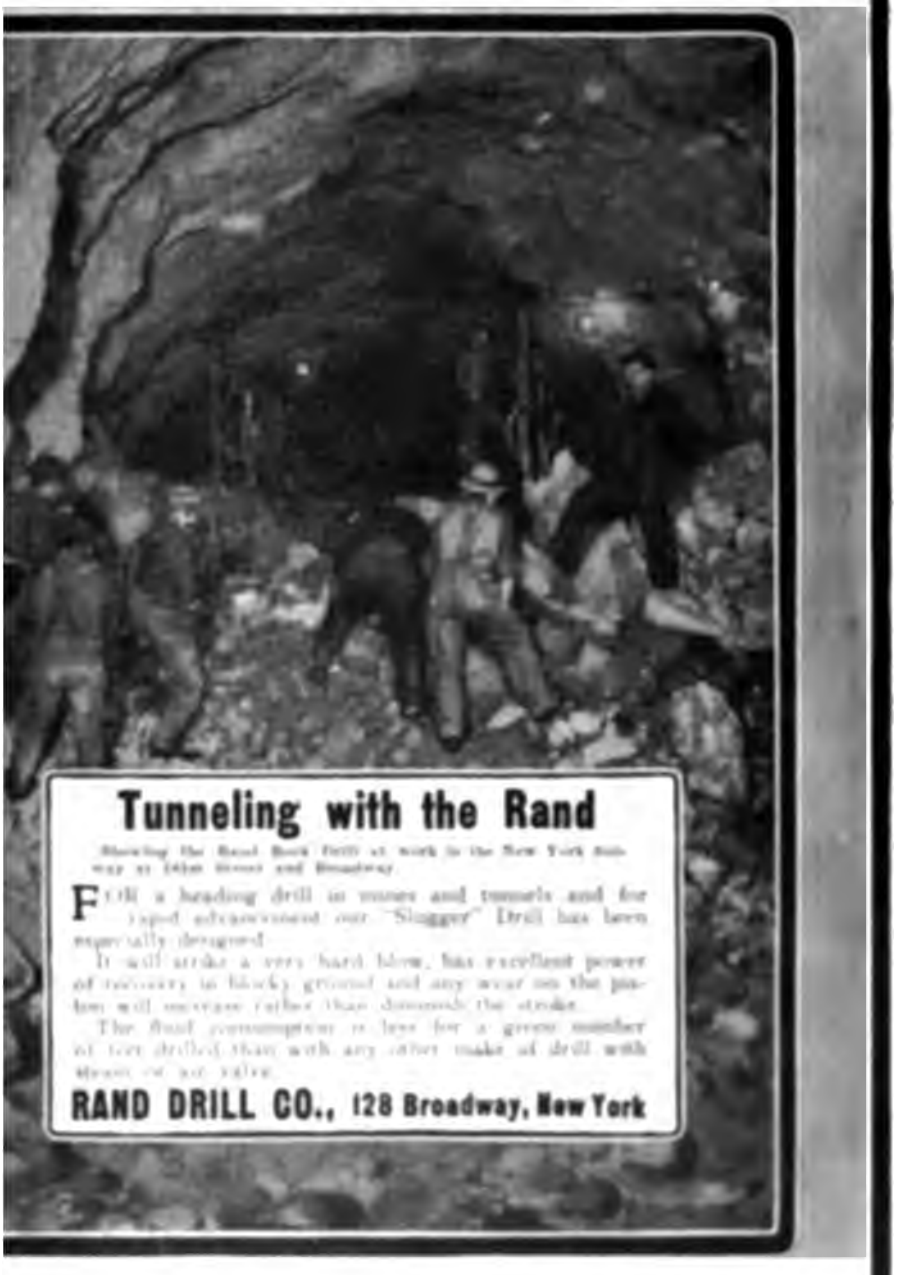

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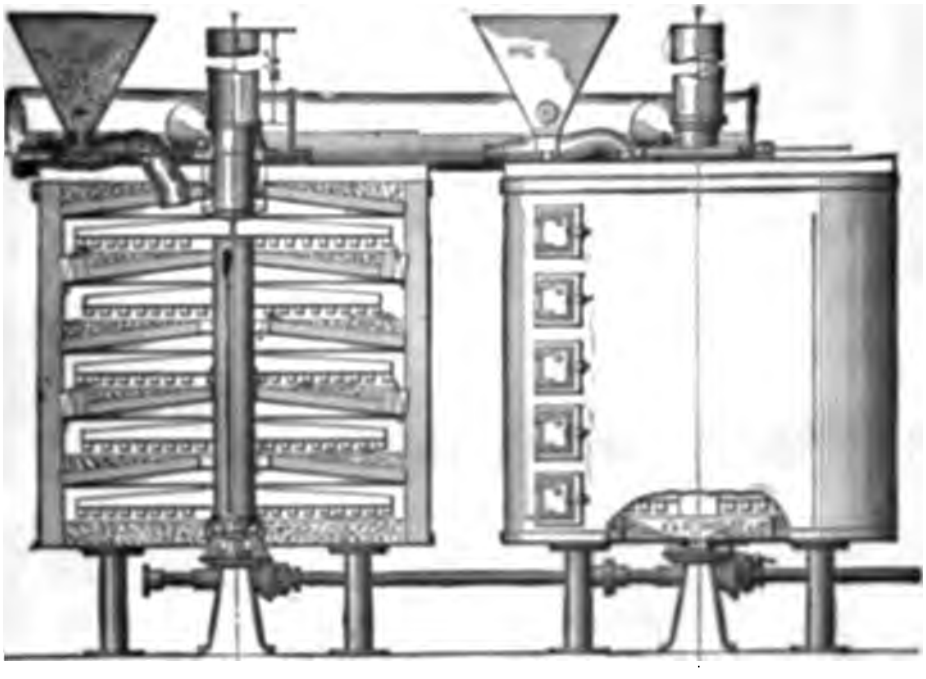

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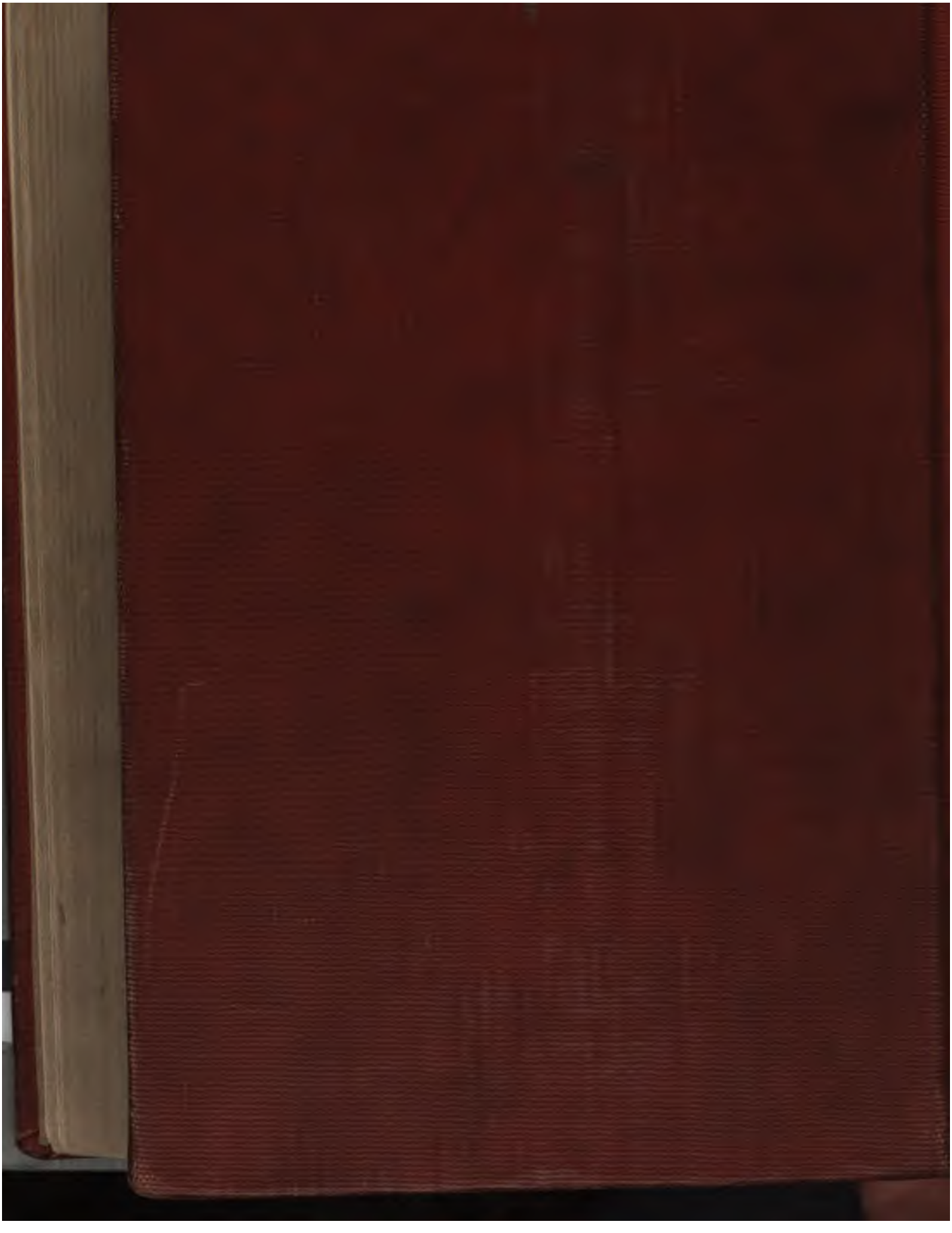
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